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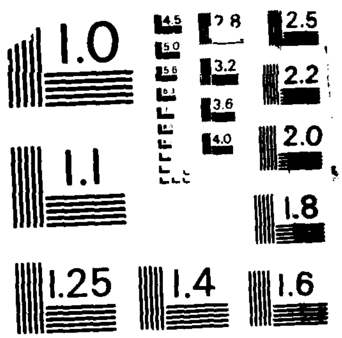

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Monterey, California

THESIS

ADAMEASURE
AN ADA® SOFTWARE METRIC

by

Jeffrey L. Nieder
and
Karl S. Fairbanks, Jr.

March 1987

Thesis Advisor: Daniel L. Davis

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19 ABSTRACT (Continue on reverse if necessary and identify by block number) Software metrics is in its infancy, is a very new field and there are many scientists and educators who would choose to keep it that way. Software metrics is held in low esteem by many software engineers. There is much debate and argument about what a good metric should do, how it should work, and what it should produce for the user. Yet with the cost of software rising, it is becoming more and more critical for future cost control and expense management that some automatic metric tool be implemented. Interest is growing, as evidenced by the Department of Defense expressing a strong interest in the development of an effective and reliable metric tool. It is no doubt that if this can be accomplished the automated software metric would be a valuable asset to the software engineering effort.

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AdaMeasure
An Ada Software Metric

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ABSTRACT

Software engineers in general, and the Department of Defense in particular, are looking for good software metrics to aid in software development. Maurice Halstead developed the theory of Software Science which includes the relation between program complexity and program length. Halstead's length metric deals with the properties of an algorithm that can be measured, either directly or indirectly, statically or dynamically, and with the relationships among these properties. A system has been developed which implements Halstead's length metric. This system, which is written in Ada, takes Ada programs as input, and outputs the length metric complexity analysis. Finally, recommendations for future work in this area are made.

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I. INTRODUCTION AND BACKGROUND

A. CONCERNS

With computer software programs getting larger and larger all the time, the search is on for accurate and dependable aids for the developer to increase the productivity and efficiency of software engineering efforts. New tools and new methodologies are being sought in the effort to alleviate the "software crisis". This crisis, stated specifically, is that software is being delivered late, over budget, specifications are not being met, modifications are difficult and expensive, unresponsive to user needs, and unreliable.

Recently, it was reported that software costs are growing at the rate of 15% per year while productivity is increasing at less than 3% [Ref. 1: p.15]. Barry Boehm, a leading computer expert, asserted more than 10 years ago that, in the military application area, the cost of software was expected to reach about 80% of the total computer system budget by the year 1985 [Ref. 2: p.1]. His assertion now seems valid [Ref. 3]. Furthermore it appears that up to 60% of the total software budget for all organizations using computers is being devoted to maintenance [Ref. 2: p.2]. The Office of Naval Research and other Defense Research agencies are aware of these increasing costs. They are also accutely aware of the lack of quantitative measurement techniques which are desperately needed for assessing the quality and reliability of software as well as for the prediction and measurement of software production [Ref. 1: p.14]. Further evidence of this universal concern comes from a General Accounting Office report of June 78 on managing weapons systems. It stated that there exists no Department of Defense performance criteria to measure software quality and to establish a basis for its acceptance or rejection [Ref. 1: p.15]. The Secretary of Defense's response was brief and candid,

> We concur. We regret and underscore the importance of the need. The Department of Defense will quickly embrace such measures when they are available.

The current Office of Naval Research (ONR) initiative to focus on software measurement is a result of the need for such metrics and the high level of interest that

the Secretary of Defense brings to bear. The ONR initiatives, stated specifically, are: developing indices of merit that can support quantitative comparisons and evaluations; designing a philosophical framework for understanding and defining software measurement; and focusing the attention of the scientific community on computer software. [Ref. 1: p.15].

B. AVAILABLE METRICS

Software metrics are often classified as either process metrics or product metrics, and are applied to either the development process or the software product being developed [Ref. 2: p.19]. Process metrics include resource metrics, such as the experience of programmers, and the cost of development and maintenance. Examples of metrics for the levels of personnel experience are the number of years that a team has been using a programming language, the number of years that a programmer has been with the organization, the number of years that a programmer has been associated with a programming team, and the number of years of experience constructing similiar software [Ref. 2: p.19]. Other factors considered in process metric measurement are development techniques (the use of top-down or bottom-up development techniques, and structured programming), supervisory techniques (such as type of team organization and number of communication paths), and resources (human, computer, time schedule, and so on) [Ref. 2: p.20]. Product metrics, on the other hand, are a measure of the software product. Product metrics include the size of the product (such as number of lines of code or some count of tokens in the program), the logic structure complexity (such as flow of control, depth of nesting, or recursion), the data structure complexity (such as the number of variables used), the function (such as type of software: business, scientific, systems, and so on), and combinations of these [Ref. 2: p.20].

The emphasis in this thesis will be on product metrics to the total exclusion of process metric issues. We are interested in analyzing the static program, or product, in our effort to provide an automated tool.

There are a variety of different quantitative software metrics in use today. In an important paper by Boehm [Ref. 4], an attempt is made to define software quality in terms of some high level characteristics such as reliability, portability, efficiency, human engineering, testability, understandability, and modifiability. If we can define these characteristics, noting that a precise subjective definition is difficult to achieve,

and measure these characteristics with some precision, we could strive to maximize each of these characteristics [Ref. 2: p.7]. There are some difficulties here. First, some of the characteristics are potentially contradictory. For example, improvements in portability and understandability usually result in decreased efficiency [Ref. 2: p.7]. Secondly, there are significant cost/benefit tradeoffs. For example, the cost of producing highly reliable code may be several times more costly, in terms of time and/or money, than for less reliable code [Ref. 2: p.7].

The measurement of software complexity is receiving increased attention in recent years. Complexity has been a loosely defined term but Bill Curtis defined complexity to be a characteristic of the software interface which influences the resources another system will expend or commit while interfacing with the software [Ref. 5]. Two separate and distinct focuses have emerged in studying software complexity: computational and psychological complexity [Ref. 1: p.208]. Computational complexity relies on the formal mathematical analysis of such problems as algorithm efficiency and use of machine resources. In contrast, the empirical study of psychological complexity has emerged from the understanding that software development and maintenance are largely human activities. Psychological complexity is concerned with the characteristics of software which affect programmer performance [Ref. 1: p.208]. This thesis will focus entirely on program complexity in an effort to provide a representative metric from selected quantitative measures.

There are a variety of complexity metrics available and we will briefly highlight a few of them. A number of metrics having a base in graph theory have been proposed to measure complexity from control flow [Ref. 1: p.210]. Thomas McCabe devised one of the better known complexity metrics in relation to the decision structure of a program [Ref. 6]. McCabe argues that his metric assesses the difficulty of testing a program, since it is a representation of the control paths that must be exercised during testing [Ref. 1: p.210]. Victor Basili and Robert Reiter [Ref. 7], have developed different counting methods for computing cyclomatic complexity by counting rules for case statements and compound predicates [Ref. 1: p.210]. Definitive data on the most effective counting rules has yet to be presented. The best known and most thoroughly studied of the composite measures of complexity is Halstead's theory of Software Science [Ref. 1: p.211]. In 1972, Maurice Halstead argued that algorithms have measurable characteristics analogous to physical laws. We will focus this thesis on Halstead's theory as the representative metric we implement. We will first look at Halstead's theory.

C. HALSTEAD

Halstead's software science theory applies the scientific method to the properties and structure of computer programs. It attempts to provide precise, objective measures of the complexity of existing software, which is then used to predict the length of the programs [Ref. 9: p.3]. Numerous statistical studies have shown very high correlations between the theory's predictions and actual program measures such as mean number of bugs [Ref. 8: p.85]. Halstead defined four basic measures:

1. n1 : The number of distinct operators appearing in a program.
2. n2 : The number of distinct operands appearing in a program.
3. N1 : The total number of occurences of the operators in a program.
4. N2 : The total number of occurences of the operands in a program.

Halstead defined the size of the *vocabulary* to be the operators plus the operands as in Equation 1.1.

$$n = n1 + n2 \qquad \text{(eqn 1.1)}$$

Halstead's theory [Ref. 8: p.11], says that actual program length can be calculated by adding the total number of operand references with the total number of operator references as in Equation 1.2.

$$N = N1 + N2 \qquad \text{(eqn 1.2)}$$

Halstead, using information theory, computes the theoretical length or predicted length as in Equation 1.3.

$$N = n1 * (\log_2 (n1)) + n2 * (\log_2 (n2)) \qquad \text{(eqn 1.3)}$$

Halstead also speaks of program volume as in Equation 1.4.

$$V = N \log_2 n \qquad \text{(eqn 1.4)}$$

The intuition is simple. For each of the N elements of a program, $\log_2 (n)$ bits must be specified to choose one of the operators or operands for that element, thus, volume (V) measures the number of bits required to specify a program [Ref. 8: p.19].

Halstead also hypothesized a conservation law between the level of abstraction and the volume. The level is defined as the ratio of potential to actual volume where the potential volume is the volume of the most compact (highest-level) representation of the algorithm [Ref. 8: p.25]. Effort, another variable that Halstead suggests, is a measure of the mental effort required to create a program. He describes effort as the ratio of volume to program level which implies that programming difficulty increases as the volume of the program increases, and decreases as program level increases [Ref. 8: p.47]. Halstead hypothesized that programming Time (T) should be directly proportional to the Effort (E) in a program, as in Equation 1.5.

$$T = E / S \qquad \text{(eqn 1.5)}$$

The constant S represents the Speed of a programmer, i.e., the number of mental discriminations per second of which he/she is capable [Ref. 8: p.48].

We agree with Alan Perlis, that regardless of the empirical support for many of Halstead's predictions, the theoretical basis for his metrics needs considerable attention [Ref. 1: p.214]. Halstead, more than other researchers, tried to integrate theory from both computer science and psychology. Unfortunately, some of the psychological assumptions underlying his work are difficult to justify for the phenomena to which he applied them [Ref. 1: p.214]. Perlis states, and again we agree, that computer scientists would do well to purge from their memories the magic number 7 + or - 2, and the Stroud number of 18 mental discriminations per second. These numbers describe cognitive processes related to the perception or retention of simple stimuli, rather than the complex information processing tasks involved in programming [Ref. 1: p.214]. Broadbent [Ref. 10], argues that for complicated tasks (such as understanding a program) the magic number is substantially less than seven. For the above reasons, this thesis will focus on the actual count of the operators and operands and will totally exclude any discussion about Halstead's other hypothesis.

D. OUR METRIC

The metric we have implemented will take, as input, an Ada program and analyze this program with respect to Halstead's length hypothesis. To properly carry out this task, the input program must be decomposed into its most basic lexical elements, and then parsed to ensure that the program is syntactically correct. As the structure of the

program is being validated the data needed for metric implementation is collected and stored for later analysis. We have designed a generic front-end for this metric tool which means other metrics can be added at a later date, thus giving the program the ability to be expanded and provide a wider range of data. We will cover each of these front-end sections in detail and describe how and why our metric operates.

II. DEVELOPING AN ADA GRAMMAR

A. INTRODUCTION

The *grammar* of a language specifies the syntax of the language and is used to help guide the translation of programs. A grammar naturally describes the hierarchial structure of many programming language constructs [Ref. 11: p.26]. A grammar has four components:

1. A set of tokens, known as *terminal* symbols.
2. A set of *nonterminals.*
3. A set of *productions* which consists of a nonterminal, an arrow, and a sequence of terminals and/or nonterminals.
4. A designation of one of the nonterminals as the *start* symbol.

Grammars are classified by many characteristics, and different parsing techniques are more or less effective on a particular class of grammar. The most efficient methods of parsing, *top-down* and *bottom-up*, which we will cover in chapter four, work only on certain subclasses of grammars. Several of these subclasses, such as the **LL** and **LR** grammars, are expressive enough to describe most syntactic constructs in programming languages [Ref. 11: p.160]. Parsers implemented by hand often work with **LL** grammars and parsers for the larger class of **LR** grammars are usually constructed by automated tools. The first **L** in **LL** stands for scanning the input from left-to-right, the second **L** for producing a leftmost derivation. Conversely the **L** in **LR** is again for left-to-right scanning of the input, the **R** for constructing a rightmost derivation in reverse [Ref. 11: p.215]. A grammar that is **LL(1)** can be deterministically parsed with a top down left to right scan by using only one token lookahead. Therefore, an **LL(1)** grammar has a parsing table with no multiply-defined entries. If the present parsing table has multidefined entries an attempt can be made to transform the grammar by eliminating all left recursion and left factoring whenever possible [Ref. 11: p.192]. There are some grammars for which no amount of alteration will yield an **LL(1)** grammar. Eliminating left recursion and then left factoring is easy to do but may make the resulting grammar hard to read and difficult to use for translation purposes. These procedures are covered in the next section.

A grammar generates strings by beginning with the start symbol and repeatedly replacing a nonterminal by the right side of a production for that nonterminal. The

terminal strings that can be derived from the start symbol form the *language* defined by the grammar [Ref. 11: p.28].

B. GRAMMAR FOR THE ADA LANGUAGE

Ada is a very large language consequently the grammar for this language is also very large. We chose to use a top-down, recursive-descent parser, which will be covered in greater detail in chapter four, as our method of analyzing our input program. We used the Ada language as defined in the Ada Language Reference Manual (LRM) [Ref. 12]. Our first step was to translate the Ada language from the Backus-Naur Form given in the Ada Language Reference Manual. In translating this grammar, which is not **LL(1)**, into an **LL(1)-like** grammar, it was necessary to *massage* the language description given in the manual. Massaging is the process of removing all left recursion and then left factoring. Left recursion is when the leftmost symbol on the right side of a production is the same as the nonterminal on the left side of the production. Left recursion must be eliminated for this top-down, recursive descent parser to alleviate the possibility of infinite looping. It must be remembered, this process does not guarantee that the transformed language will be **LL(1)**. However, we must be sure to perform transformations that lead to a grammar for the same language. The remainder of this chapter is devoted to the discussion and explanation of how we massaged the grammar. The complete grammar used by our parser can be found in Appendix A. Our translation key has terminal symbols as lowercase letters, non-terminal symbols as uppercase letters, and bold-faced symbols to indicate the meta-symbols of our grammar.

Once the initial grammar is expressed in our meta-symbology, the next step is to remove all left recursion. Since the BNF form in the LRM showed no left recursion, it appeared that this step would not be required. However, there was one case of left recursion that was not apparent until several substitutions of the productions had been made. This case involved the production rules for NAME, INDEXED_COMPONENT, SLICE, SELECTED_COMPONENT, ATTRIBUTE, and PREFIX. The production rules, when taken directly from the LRM, appear as the follows:

```
NAME --> identifier
     --> character_literal
     --> string_literal
     --> INDEX_COMPONENT
```

```
        --> SLICE
        --> SELECTED_COMPONENT
        --> ATTRIBUTE

  INDEXED_COMPONENT --> PREFIX (EXPRESSION)

  SLICE --> PREFIX (DISCRETE_RANGE)

  SELECTED_COMPONENT --> PREFIX.SELECTOR

  ATTRIBUTE --> PREFIX'ATTRIBUTE_DESIGNATOR

  PREFIX --> NAME
         --> FUNCTION_CALL
```

When starting with NAME and substituting in the productions, the left recursion becomes readily apparent. For example:

```
NAME --> SLICE --> PREFIX(DISCRETE_RANGE) ==> NAME(DISCRETE_RANGE)
```

We see that the following production exists:

```
NAME --> NAME (EXPRESSION)
```

Several other productions, left recursive on NAME, can be generated using the other rules listed above.

Now that left recursion does exist, we expanded out the productions listed above (using the same technique previously demonstrated) and combined them all as production rules for NAME. The production rules for INDEXED_COMPONENT, SLICE, SELECTED_COMPONENT, and ATTRIBUTE were incorporated into NAME so they were removed from our grammar. The final set of production rules for NAME can be found in Appendix A.

The third step in massaging our grammar is left factoring. Our parser could not function with one token lookahead if left factoring were possible. Left factoring is a grammar transformation which uses the basic idea that if it is not clear which of two alternative productions to use to expand a nonterminal, it may be possible to rewrite the productions to defer the decision until we have enough of the input to make the correct decision. To demonstrate this procedure, we will show the left factoring used on the productions for RELATION. Taken directly from the LRM the production rules for RELATION are as follows:

```
RELATION --> SIMPLE_EXPRESSION
         --> SIMPLE_EXPRESSION RELATIONAL_OPERATOR SIMPLE_EXPRESSION
         --> SIMPLE EXPRESSION in RANGES
         --> SIMPLE_EXPRESSION not in RANGES
         --> SIMPLE_EXPRESSION in TYPE_MARK
         --> SIMPLE_EXPRESSION not in TYPE_MARK
```

Applying the rule of left factoring, a new nonterminal, SIMPLE_EXPRESSION_TAIL, has been added to the grammar. The production rules for RELATION and SIMPLE_EXPRESSION_TAIL now look like the following:

```
RELATION --> SIMPLE_EXPRESSION  SIMPLE_EXPRESSION_TAIL

SIMPLE_EXPRESSION_TAIL  --> RELATIONAL_OPERATOR  SIMPLE_EXPRESSION
                        --> in RANGES
                        --> not in RANGES
                        --> in TYPE_MARK
                        --> not in TYPE_MARK
```

Finally, in attempting to make our grammar **LL(1)** it was necessary to combine several similar constructs together so that it could be parsed by one function of the parser. For example, the reserved word **package** appears in several instances including a package specification, a package body declaration, a separate package body declaration, a generic instantiation of a package, and the renaming of a package. In each of these examples the reserved word **package** is used, and even with the ablility to look ahead one token, it is impossible to tell which form of the package construct is being utilized. We massaged our grammar so that if **package** is encountered the function PACKAGE_DECLARATION is called. The function PACKAGE_DECLARATION first checks for the reserved word **body**, indicating a package body declaration, or a separate package body declaration. PACKAGE_DECLARATION then checks for an identifier, indicating a package specification, a generic instantiation, or a renaming declaration. If **body** is present then the function PACKAGE_BODY is called. If an identifier is present then the function PACKAGE_UNIT is called. This technique of decision making based on reserved word or terminal symbol presence is extended into the functions

PACKAGE_BODY and PACKAGE_UNIT to further decide which form of **package** is being utilized. In essence, we have expanded the production rules to allow each new production the ability to correctly determine, with one token lookahead, what the next production rule will be. This entire process is also used for the different versions of **procedures, functions,** and **tasks** which can appear in an Ada program.

III. LEXICAL ANALYZER

A. INTRODUCTION

Ada is an extremely large language, comparable in size to PL1. It was developed on behalf of the Department of Defense for use in embedded systems [Ref. 13: p.xi]. Based on Pascal, Ada is the first practical language to bring together important features such as data abstraction, multitasking, exception handling, encapsulation and generics [Ref. 13: p.xi]. Our design approach utilizes a division of labor and we separate our metric into phases which perform a single, specific function. The first two phases, *lexical analysis* and *parsing*, combine to form a generic *front-end machine*. This front-end machine constructs an intermediate representation of the source program. The information necessary to implement the metric is then collected and analyzed from the intermediate form. We will look, in depth, at the lexical analyzer and identify how it operates and why it is necessary.

B. TOKENS

Lexical Analysis, often called linear analysis or scanning, is when a stream of characters making up the source program is read from left-to-right and grouped into *tokens*, which are sequences of characters having a collective meaning [Ref. 11: p.4]. The character sequence forming a token, with the legal characters as described in [Ref. 12: p.2-1], is called the *lexeme* for the token. This lexeme is what is used to identify the actual operators and operands that serve as the input for our metric. All variables will have a lexeme, such as *sqrt*, *rate*, *answer*, and so on. There are seven token classes in the Ada language. They are *identifiers*, *separators*, *numeric literals*, *delimiters*, *comments*, *character literals*, and *string literals*. The *lexical analyzer* takes the source program one character at a time, and builds the token lexeme as it determines the token class. Each token is generated by a *finite state automaton*. A finite state automaton, often called a finite state machine, is a mathematical model for a device that is capable of recognizing strings of characters defined by a certain class of grammars, called regular grammars. Our scanner, or lexical analyzer, can be in any one of a finite number of internal configurations or *states* [Ref. 14: p.13]. The state of the system summarizes the information concerning past inputs that is needed to determine the behavior of the system on subsequent inputs. The lexical analyzer scans

the symbols of a computer program to locate the strings of characters corresponding to one of the seven token types mentioned earlier. In this process the lexical analyzer needs to remember only a finite amount of information, such as how long a prefix of a reserved word it has seen since startup [Ref. 14: p.14].

We will now address these tokens individually and discuss not only their purpose and content but also the finite state machines we programmed to handle their recognition.

1. Identifiers

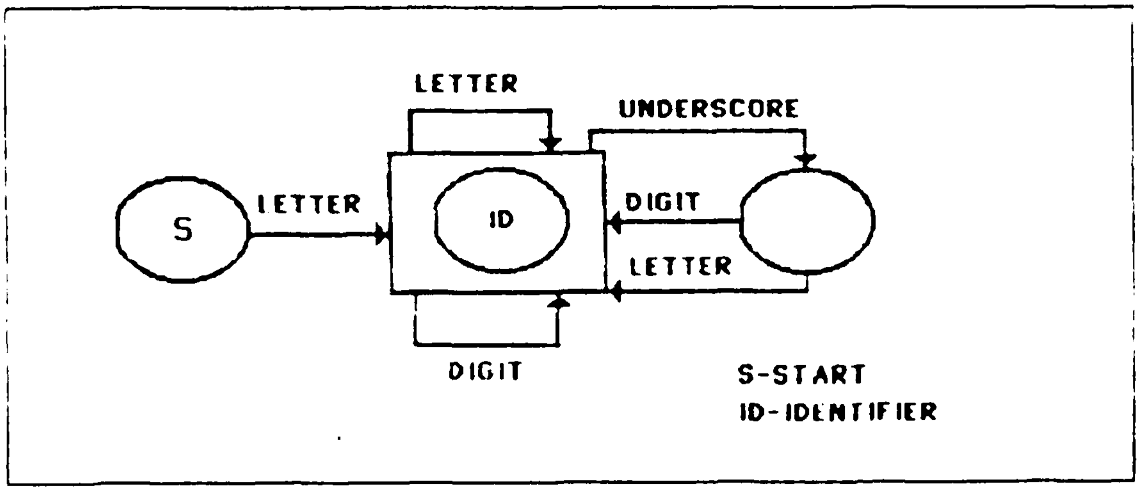

Figure 3.1 Finite State Machine for Identifiers.

Identifiers are used as names and also as reserved words [Ref. 12: p.2-4]. An identifier must start with a letter and it can then be any combination of letters, digits or the underscore character (_). There cannot be two underscore characters side by side in the identifier and there is no maximum length specified for any identifier. Identifiers differing only in the use of corresponding upper and lower case letters are considered as the same [Ref. 12: p.2-4]. The finite state machine we programmed to identify and store token *identifiers* is seen in Figure 3.1.

2. String Literal

A string literal is formed by a sequence of zero or more graphic characters enclosed between two quotation characters (") used as string brackets [Ref. 12: p.2-6]. A string literal has a value that is a sequence of character values corresponding to the graphic characters of the string literal apart from the quotation character itself

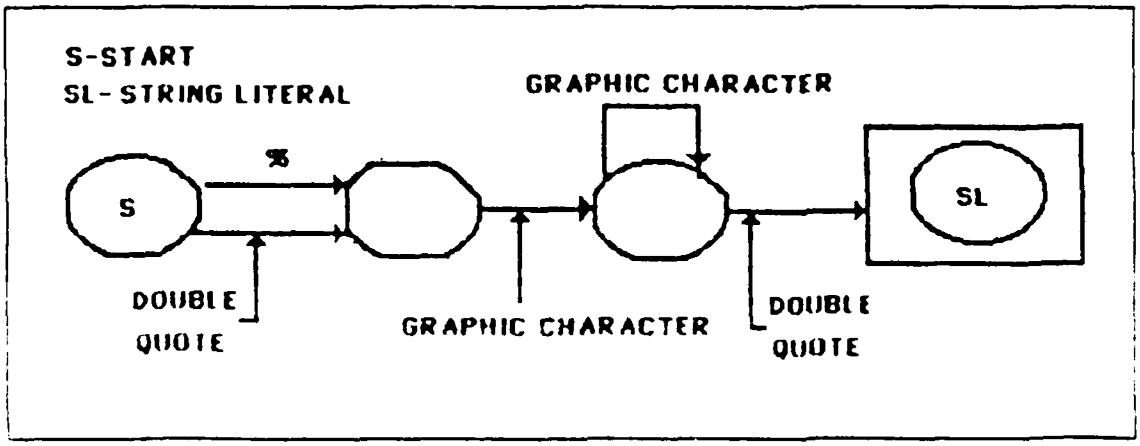

Figure 3.2 Finite State Machine for String Literals.

[Ref. 12: p.2-6]. If a quotation character value is to be represented in the sequence of character values, then a pair of adjacent quotation characters must be written at the corresponding place within the string literal. The length of a string literal is the number of character values in the sequence represented, except for doubled quotation characters which are counted as a single character [Ref. 12: p.2-6]. A string literal must fit on one line since it is a lexical element but longer sequences of graphic characters can be obtained by catenation of string literals [Ref. 12: p.2-7]. Except for the instance of doubled quotation characters, the finite state machine we programmed to identify and store token *string literals* can be seen in Figure 3.2.

3. Character Literals

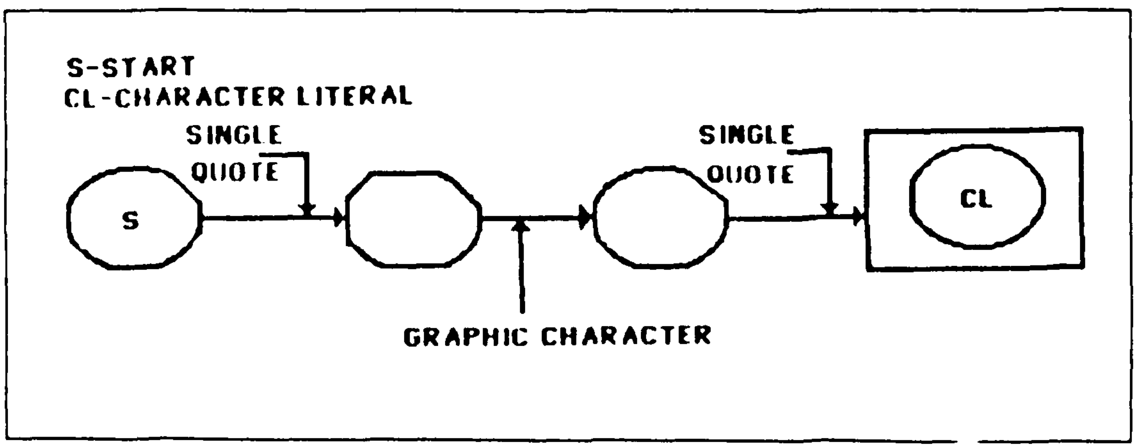

Figure 3.3 Finite State Machine for Character Literals.

A character literal is formed by enclosing one of the 95 graphic characters (including the space), which are described in [Ref. 12: p.2-1], between two apostrophe characters ('). A character literal has a value that belongs to a character type. The finite state machine we created to identify and store token *character literals* can be seen in Figure 3.3.

4. **Comments**

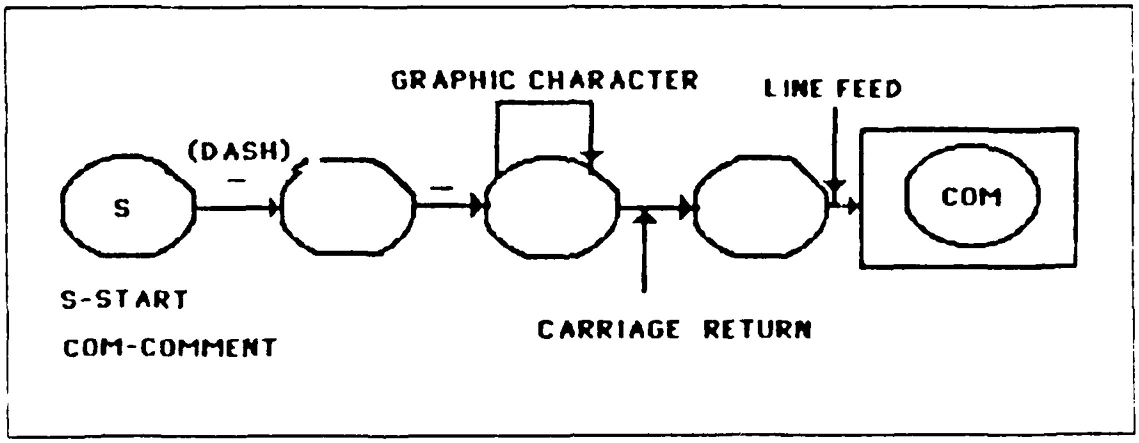

Figure 3.4 Finite State Machine for Comments.

A comment starts with two adjacent hyphens and extends up to the end of the line. A comment can appear on any line of a program [Ref. 12: p.2-7]. The presence or absence of comments has no influence on whether a program is legal or illegal. Furthermore, comments do not influence the effect of a program. The sole purpose of comments is to provide clarity and explanation to the human reader. The horizontal tabulation can be used in comments, after the double hyphen, and is equivalent to one or more spaces [Ref. 12: p.2-7]. The finite state machine we programmed to identify and store token *comments* can be seen in Figure 3.4.

5. **Separators**

In certain cases an explicit separator is required to separate adjacent lexical elements (namely, without separation, interpretation as a single lexical element is possible) [Ref. 12: p.2-3]. A separator is any of a space character, a format effector (such as horizontal tabulation, vertical tabulation, carriage return, line feed, and form feed), or the end of a line [Ref. 12: p.2-3]. A space character is a separator except within a comment, a string literal, or a space character literal. The horizontal

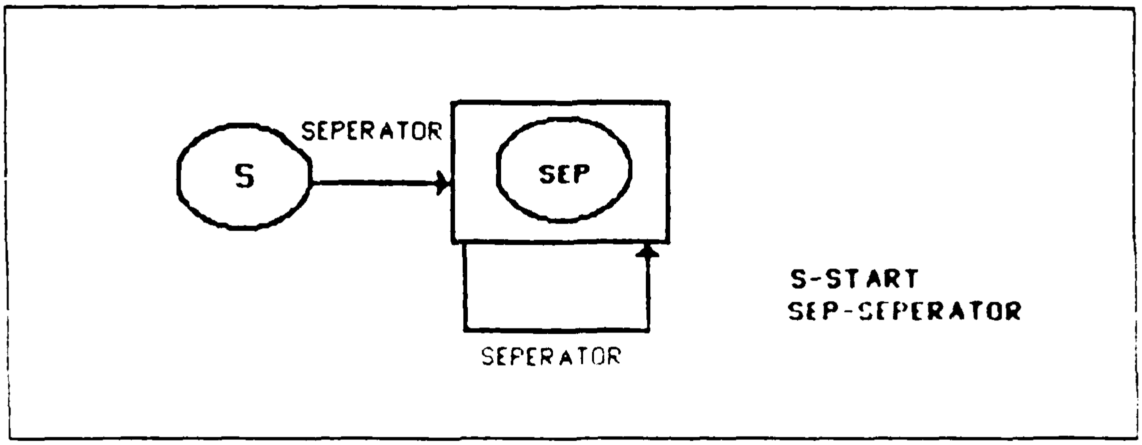

Figure 3.5 Finite StateMachine for Separators.

tabulation is not a separator within a comment. One or more separators are allowed between any two adjacent lexical elements (tokens), and at least one separator is required between an identifier or a numeric literal and an adjacent identifier or numeric literal. The finite state machine we programmed to identify and store token *separators* is seen in Figure 3.5.

6. **Delimiters**

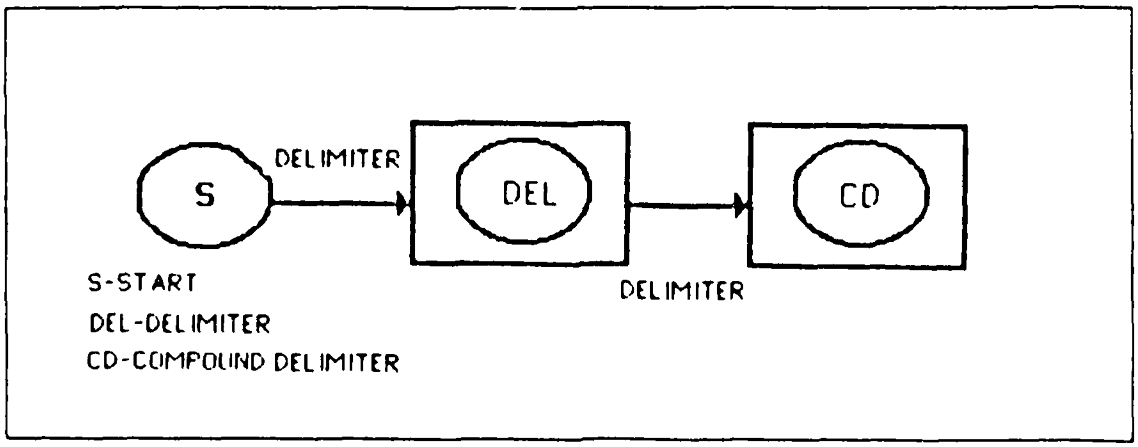

Figure 3.6 Finite State Machine for Delimiters.

A simple delimiter is either one of the following special characters (in the basic character set):

& ' ( ) * + , . / ; < = > | :

A compound delimiter is one of the following, each composed of two adjacent special characters

=> .. ** := /= >= <= >> << <>

Any other combination of adjacent special characters is not a legal compound delimiter. The finite state machine we programmed for identifying and storing token *delimiters* is seen in Figure 3.6.

7. **Numeric Literal**

The numeric literal is by far the most complex and varied type of token. It encompasses real numbers, integer numbers, and based numbers which are numeric literals expressed in an explicitly specified base between 2 and 16 [Ref. 12: 2-5], p. A real number is a number with a decimal point, an integer is a number without a point and a based literal is, again, a number whose base is explicitly stated. An underline character (_) inserted between adjacent digits of a numeric literal does not affect the value of this numeric literal. The only letters allowed as extended digits are the letters A through F, which stand for the digits ten through fifteen in hexidecimal. A letter in a based number can be written either in lower case or in upper case, with the same meaning [Ref. 12: p.2-5]. Leading zeros are allowed. No space is allowed in a numeric literal, not even between constituents of the exponent, since a space is a separator. A zero exponent is allowed for an integer literal. The finite state machine we programmed to identify and store token *numeric literals* can be seen in Figure 3.7.

C. TOKEN USE

As was seen in Chapter II, a grammar is made up of terminals, non-terminals, a start symbol, and productions. The terminals are the basic symbols from which strings are formed. These strings are the combinations of the most basic symbols, *tokens*, which form meaningful expressions to a particular language. To be able to analyze these strings and determine whether or not a given string is a legal statement in any given language we must first identify each token as it is entered by the program. Identification of the tokens permits the computer to compact the incoming data thus allowing the saving of space. For example, if someone placed ten blanks in an input program where only one was needed, lexical analysis would see the separator and flush the other unused blanks, thus saving space. Certain tokens will be augmented by a *lexical value*. For example, when an identifier like *rate* is found, the lexical analyzer not only generates a token, say *id*, but also enters the lexeme *rate* into the symbol

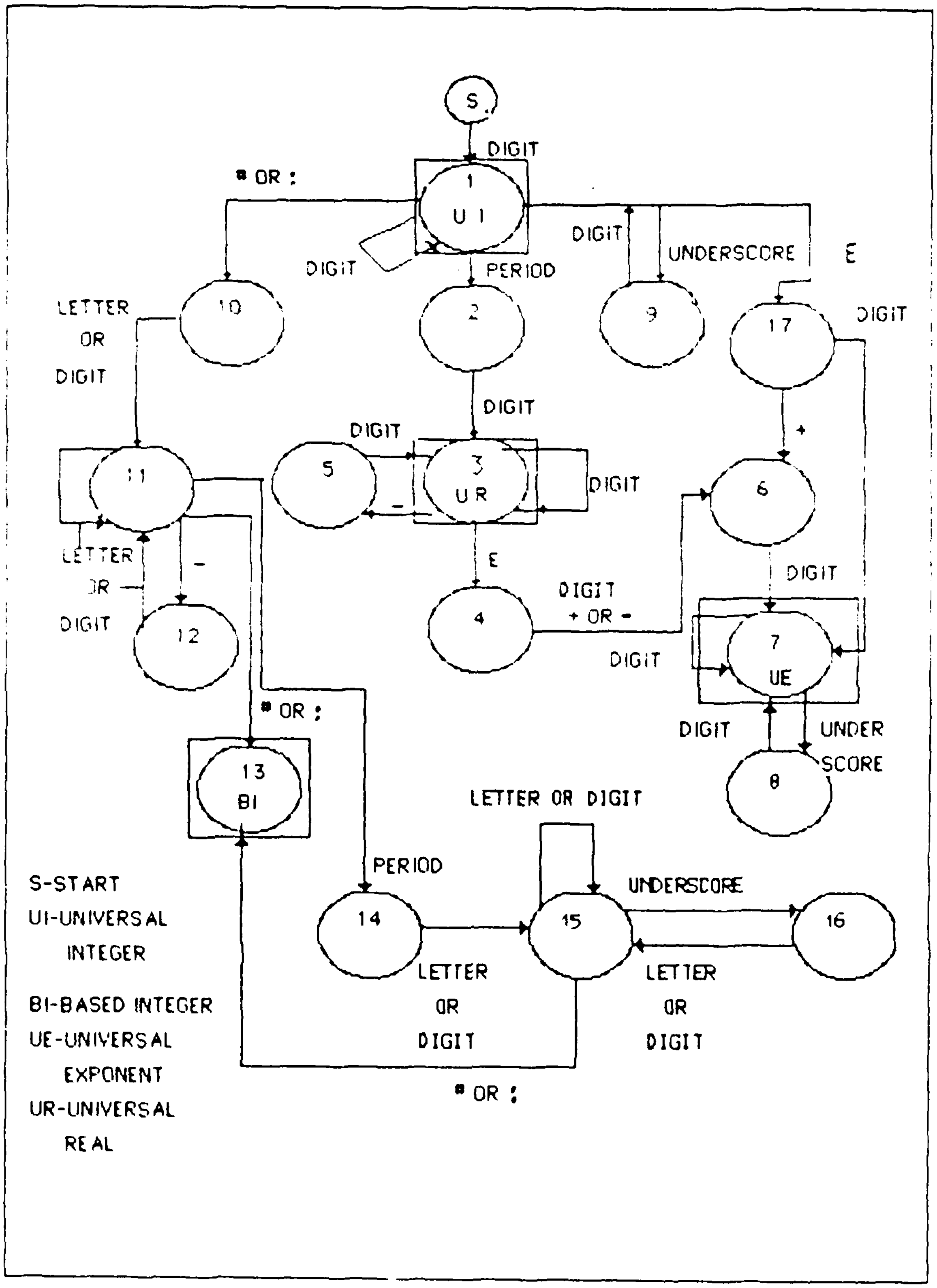

Figure 3.7 Finite State Machine for Numeric Literals.

table, if it is not already there [Ref. 11: p.12]. The lexical value associated with this occurence of *id* points to the symbol-table entry for *id*. The construction of these tokens is done by reading one character at a time and building the lexeme of the token by appending the appropriate characters together. This translation from the input program to a simple stream of tokens is the sole job of the lexical analyzer. In the next chapter we will look at the system parser and its functions.

IV. PARSER

A. INTRODUCTION

The parser, which is the second component of our front-end machine, is the mainstay of our metric. Parsing is also called hierarchical analysis or syntax analysis. It involves grouping the tokens, created by the lexical analyzer, of the source program into grammatical phrases that are used to synthesize output [Ref. 11: p.6]. A parser can be constructed for any context-free grammar. The important factor in parsing is speed. Given a programming language, we can generally construct a grammar that can be parsed quickly. Most programming language parsers make a single left-to-right scan over the input, looking ahead one token at a time [Ref. 11: p.41]. In discussing this parsing problem, it is helpful to think of a parse tree being constructed, even though our *front-end machine* does not actually construct a tree. A parse tree describes the syntactic structure of the input. It pictorially shows how the start symbol of a grammar derives a string in the language [Ref. 11: p.29]. Formally, given a context-free grammar, a parse tree is a tree with the following properties:

1. The root is labeled by the start symbol.
2. Each leaf is labeled by a token or empty string.
3. Each interior node is labeled by a nonterminal.

The leaves of a parse tree, read from left to right, form the *yield* of a tree, which is the string generated or derived from the nonterminal at the root of the parse tree [Ref. 11: p.29]. The term, *context-free grammar*, which is mentioned earlier, defines a finite set of variables (also called nonterminals or syntactic categories), each of which represents a language [Ref. 14: p.77]. A *context-free grammar* is denoted G = (V,T,P,S), where V and T are finite sets of variables and terminals respectively [Ref. 14: p.79]. P is a finite set of productions; each production (A = > W) is of the form *A* produces *W* where *A* is a variable and *W* is a string of symbols from any combination of (V union T). Finally, S is the start symbol. It must be noted though that although our front-end machine is capable of constructing a parse tree (otherwise the translation would not be guaranteed correct) the actual tree is not necessary for our metric purposes and is therefore not built.

Most parsing methods fall into one of two classes, *top-down* and *bottom-up* methods [Ref. 11: p.41]. These terms refer to the order in which nodes in the parse tree, if the tree actually existed, were constructed. In the top-down method, construction starts at the root and proceeds towards the leaves going deeper and deeper until eventually reaching the bottom. In the bottom-up method it is just the opposite. Construction starts at the bottom and proceeds towards the root. The popularity of top-down parsers is due to the fact that efficient parsers can be constructed more easily by hand using top-down methods [Ref. 11: p.41]. Bottom-up parsing, however, can handle a larger class of grammars and translation schemes, so software tools for generating parsers directly from grammars have tended to use bottom-up methods [Ref. 11: p.41]. Because of its efficiency and ease of use, we have chosen to use the top-down method of parsing for the front-end machine of our metric. Furthermore, we chose a particular type of top-down parsing called recursive-descent. This technique, a classical method often used in industry, is very powerful. We describe its operation in the following section.

B. TOP-DOWN RECURSIVE DESCENT PARSING

Recursive-descent parsing is a top-down method of syntax analysis in which we execute a set of recursive procedures to process the input [Ref. 11: p.44]. A function is associated with each nonterminal of a grammar. We now consider a special form of *recursive-descent* parsing, called predictive parsing, in which the token symbol unambiguously determines the function selected for each nonterminal [Ref. 11: p.44]. The sequence of functions called in processing the input implicitly defines a parse tree for the input.

Our procedure GET_CURRENT_TOKEN_RECORD builds an array of fifty tokens and, starting at the initial position controls a pointer which identifies the current token being parsed and another pointer which identifies the next or *lookahead* token to be parsed. The function BYPASS is the central control and workhorse for our parser. It compares the current token with predefined terminals. If there is a token-to-terminal match, BYPASS consumes the token by adjusting the index pointers. All of the terminal symbols in the Ada language are defined and any nonterminal is, as was stated earlier, a function call that returns a boolean value of true or false.

Parsing begins with a call for the starting nonterminal, which is COMPILATION in the Ada grammar. Parsing progresses as each function calls other functions,

descending into the parse structure until a call to BYPASS is performed and the appropriate boolean value is returned. This process of ascending and descending the parse structure continues until all the tokens created from the input file have been consumed or an error occurs.

We made an attempt to design the parser to be as robust as possible. However, due to the complexity of the language we were often forced to rely on the fact that the input file had been correctly compiled before being fed into our parser. The fact that the input file was precompiled allowed us to drop the *italicized* element of the nonterminals in the grammar. Some examples of this modification are:

1. A parser for a compiler would normally have to remember the type associated with NAME each time it was encountered. In our case we simply dropped the type requirement and parsed all of them with the function NAME. For example, all of the following are reduced to just NAME: TYPE_NAME, VARIABLE_NAME, PROCEDURE_NAME, FUNCTION_NAME, ENTRY_NAME, and this list is far from complete.

2. Another example occured when we dropped the italicized element of the nonterminal EXPRESSION. Since the type had been checked by a full compiler, for our parser the following three nonterminals became simply EXPRESSION: UNIVERSAL_STATIC_EXPRESSION, QUALIFIED_EXPRESSION, and BOOLEAN_EXPRESSION. The following two nonterminals became SIMPLE_EXPRESSION for the same reasons: STATIC_SIMPLE_EXPRESSION, and DELAY_SIMPLE_EXPRESSION.

3. Our third example is that by dropping the italicized element of DISCRETE_SUBTYPE_INDICATION and COMPONENT_SUBTYPE_INDICATION, they can both be correctly parsed by SUBTYPE_INDICATION.

The changes highlighted above, and others that are not shown, were done to reduce the size and complexity of the parser. Having to retain all the type information would have required a much more extensive parsing element. This reduction allows our parser to be more efficient in its operation. We did not intend for our front-end machine to be a full compiler. We only needed to parse an input file in enough detail to be able to collect the meaningful and relevant metric data.

V. ADAMEASURE

A. INTRODUCTION

As was seen in the first chapter of our thesis there is a variety of different metric theories. By request of the Missile Software Branch, Naval Weapons Center, China Lake, we implemented the Halstead Software Science Metric. In the effort to provide as much information about the input program as possible, we also provide information on comments and nesting. We felt it was important to avoid trying to generate a single number, say betweeen one and ten, which would be an attempt to quantify the given metric information into a single numeric statement. Instead we generate a few important numbers, then we apply some reasoning to what we believe these numbers mean in relation to program complexity and overall software quality. We stress what the program says about the software is merely suggestive.

B. DATA COLLECTION

In explaining the how and why of our data gathering, we will deal with each of the three types of information analysis separately.

1. Halstead Data

As stated in chapter one, we only implemented the program length metric from Halstead's software science theory. We gathered the *operator* data through our workhorse function BYPASS which counted every token-to-operator terminal match. To acquire the *operand* data we generated a symbol table of all identifiers, be they variables, procedures, functions, tasks, blocks, or numeric constants. Once this was completed we now had the four Halstead parameters n1, n2, N1, and N2. Having calculated the *theoretical length* and *actual length* we divided both of these numbers by *total lines input* to allow comparisons of results from programs of different size.

If the actual length is greater than the theoretical length Halstead hypothesized that the difference is caused by one or more of the following six classes of impurities.

- Cancelling : The occurence of an inverse cancels the effect of a previous operator; no other use of the variable changed by the operator is made before the cancellation.
- Ambiguous operands : The same operand is used to represent two or more variables in an algorithm.

- Synonymous operands : Two or more operand names represent the same variable.
- Common subexpressions : The same subexpression occurs more than once.
- Unnecessary replacements : A subexpression is assigned to a temporary variable which is used only once.
- Unfactored expressions : There are repetitions of operators and operands among unfactored terms in an expression.

If the theoretical length is greater than the actual length then the following conditions could exist:

- Operands : There may be some variables which were declared but never referenced in the program.
- Globals : A large number of the variables referenced were declared in the packages instantiated by the WITH statement.

2. Comment Data

As the input file is parsed, a count is kept of the comment lines. Upon completion of parsing the number of comment lines is divided by the total lines input, then multiplied by one-hundred to yield the overall comment percentage. On the basis of this percentage we make recommendations, that might prove helpful to the software engineer. Briefly, we consider a comment percentage between zero and fifteen percent as low and we state that unless the program utilizes Ada's extensive variable identification ability then there may be too few comments for adequate reader comprehension. We consider a comment percentage between fifteen and fifty as a reasonable number and state that this could give the reader a good understanding of the program. A comment percentage between fifty and eighty-five percent is considered fairly high and we state that the program has good understandability but runs a small risk of obscuring the code. Lastly, a comment percentage between eighty-five and one-hundred percent is an extremely high percentage and we say that the program has a higher possibility of obscuring the code in the high number of comments.

3. Nesting Data

Determining a program's complexity is not an easy thing but it is generally accepted that as the nesting level increases so goes the complexity level. We have implemented a nesting level summary which counts how frequently a given nesting level was reached, maintains a record for each level, and keeps track of the maximum level used and where it was first encountered.

VI. CONCLUSIONS

A. METRICS

The Department of Defense's interest in metrics provides a powerful motivation for the continued research into possible metric tools. The software crisis is severe enough to warrant tools, aids, just any bit of information that will improve the software engineering process. Computer Science is such an infant in the world of academia and metrics is such a very small part of this child that we are aware of the difficulty in finding breakthroughs. The computer scientists may have tried to "catch-up" with the other sciences much too rapidly, consequently they may have missed laying some of the necessary foundations.

Our initial effort is a good start, a baseline from which future efforts can build upon. AdaMeasure is a helpful tool for providing the software engineer with the information that is presently gathered by hand. We do not feel software metrics should simply attempt putting a number onto a program in the effort to quantify its quality. Text describing what the metric has seen and how it relates to the programmer and the program is what is really needed for the output. It is this bridging from the concrete world of the metric to the abstruse, metaphysical environment of the actual software that presents the real challenge. As we collect and analyze the data, we bridge this gap by providing recommendations to the user on how we see the interrelationship of these two entities. These recommendations are based on currently accepted software practices.

B. IMPLEMENTATION

In our effort to make the Ada grammar more LL(1)-like we were forced to perform extensive massaging. This massaging allowed us to use the top-down, recursive-descent parsing technique. This classical, time tested method proved to be easily implemented and debugged. The extensive massaging made it necessary for us to frequently check and reaffirm that the language generated by our newly transformed grammar was exactly the same as the initial language. This point cannot be overstated. The languages must be identical. Because of the complexity involved in massaging and checking the grammar, we feel we have some insight into how languages are created, how they build upon themselves, and where languages are going in the future.

When we originally accepted the proposal for creating a metric, we were not aware of how complex and time consuming the implementation of the front-end machine would be. This complextiy, coupled with the fact that Ada is a brand new language and relatively unknown other than by name, made it a struggle until we had significantly progressed along the learning curve. We found the Ada compiler, which is currently a state-of-practice compiler, to be extremely slow in comparison to the compilers we were familiar with such as Pascal or Fortran. The Naval Postgraduate School has no Ada compiler so we were forced to work over Arpanet or Telnet for the actual programming. This presented problems and delays on a regular basis. The expiration of access card numbers, the malfunctioning of the bridge box, the networks going down, the slow baud rate between stations, and machine downtime at NWC China Lake, both scheduled and nonscheduled, made information transfer a real hurdle in the overall effort.

C. THE FUTURE

Having designed a generic metric tool, we hope the program will be expanded and improved. There is already a plan in progress to have Sallie Henry and Dennis Kafura's Complexity Flow Metric implemented. There is a real need for user interface improvements. Because of the limited hardware options available to us, we have programmed our interface to deal with the VT-100 terminal. To make the system more robust and transportable, an interface scheme that would be functional from a variety of different terminals would be a useful endeavor.

This metric was undertaken at the request of NWC China Lake and all of our efforts have been guided by their input to us. Pragmas, which are used to convey information to the compiler, are currently being used in run-time systems only at China Lake and although they are in the Ada grammar we have not implemented them in our metric. It would greatly increase the value of the program if the pragma portion of the grammar were implemented. The Software Missile Branch of NWC China Lake has provided all the Ada programs at their disposal to help us test our metric for proper parsing. We have successfully tested our metric on all these files and we have successfully tested our own code by feeding our metric into itself. Although our tests have been successful we have not tested all of our code. There is a particular need for programs that will test our metric in the area of tasking and all the code that is associated with it. This testing effort should be carried our as soon as possible.

Metrics are important. We hope that our initial work will be expanded and put to real use as a aid to the software engineer. Although Ada is new and relatively unexplored as a language, we feel it will begin to build and become more popular. We hope our metric adds to this building process.

APPENDIX A

MODIFIED ADA GRAMMAR

Our translation key has terminal symbols as lowercase letters, nonterminal symbols as uppercase letters, and bold-faced symbols to indicate the meta-symbols of our grammar.

```
(9.10) (parser3)
ABORT_STATEMENT --> NAME [ , NAME]*

(9.5) (parser1)
ACCEPT_STATEMENT --> identifier [ (EXPRESSION) ?] [ FORMAL_PART ?]
                     [ do SEQUENCE_OF_STATEMENTS end [ identifier ?] ?] ;

(4.3) (parser3)
AGGREGATE --> (COMPONENT_ASSOCIATION [ , COMPONENT_ASSOCIATION]* )

(4.8) (parser3)
ALLOCATOR --> SUBTYPE_INDICATION [ 'AGGREGATE ?]

(3.6) (parser3)
ARRAY_TYPE_DEFINITION   --> (INDEX_CONSTRAINT of SUBTYPE_INDICATION

(5.2) (parser2)
ASSIGNMENT_OR_PROCEDURE_CALL --> NAME := EXPRESSION ;
                             --> NAME ;

(4.1.4) (parser3)
ATTRIBUTE_DESIGNATOR --> identifier [ (EXPRESSION) ?]
                     --> range [ (EXPRESSION) ?]
                     --> digits [ (EXPRESSION) ?]
                     --> delta [ (EXPRESSION) ?]

(3.1) (parser1)
BASIC_DECLARATION --> type TYPE_DECLARATION
                  --> subtype SUBTYPE_DECLARATION
                  --> procedure PROCEDURE_UNIT
                  --> function FUNCTION_UNIT
                  --> package PACKAGE_DECLARATION
                  --> generic GENERIC_DECLARATION
                  --> IDENTIFIER_DECLARATION
                  --> task TASK_DECLARATION

(3.9) (parser1)
BASIC_DECLARATIVE_ITEM  --> BASIC_DECLARATION
                        --> REPRESENTATION_CLAUSE
                        --> use WITH_OR_USE_CLAUSE

(10.1) (parser0)
BASIC_UNIT  --> LIBRARY_UNIT
            --> SECONDARY_UNIT

(4.5) (parser4)
BINARY_ADDING_OPERATOR  --> +
                        --> -
                        --> &

(5.6) (parser1)
BLOCK_STATEMENT --> [ identifier : ?] [ declare DECLARATIVE_PART ?] begin
                    SEQUENCE_OF_STATEMENTS [ exception [ EXCEPTION_HANDLER]+ ?] ?]
                    end [ identifier ?] ;
```

```
(5.4) (parser1)
CASE_STATEMENT --> EXPRESSION is [ CASE_STATEMENT_ALTERNATIVE]+ end case ;

(5.4) (parser1)
CASE_STATEMENT_ALTERNATIVE --> when CHOICE [ | CHOICE]* => SEQUENCE_OF_STATEMENTS

(3.7.3) (parser3)
CHOICE    --> EXPRESSION [ ..SIMPLE_EXPRESSION ?]
          --> EXPRESSION [ CONSTRAINT ?]
          --> others

(10.1) (parser0)
COMPILATION --> [ COMPILATION_UNIT]+

(10.1) (parser0)
COMPILATION_UNIT --> CONTEXT_CLAUSE  BASIC_UNIT

(4.3) (parser3)
COMPONENT_ASSOCIATION --> [ CHOICE [ | CHOICE]* => ?] EXPRESSION

(3.7) (parser2)
COMPONENT_DECLARATION --> IDENTIFIER_LIST : SUBTYPE_INDICATION [ := EXPRESSION ?] ;

(3.7) (parser2)
COMPONENT_LIST --> [ COMPONENT_DECLARATION]* [ VARIANT_PART ?]
               --> null ;

(5.1) (parser1)
COMPOUND_STATEMENT   --> if IF_STATEMENT
                     --> case CASE_STATEMENT
                     --> LOOP_STATEMENT
                     --> BLOCK_STATEMENT
                     --> accept ACCEPT_STATEMENT
                     --> select SELECT_STATEMENT

(3.2) (parser2)
CONSTANT_TERM  --> array CONSTRAINED_ARRAY_DEFINITION [ := EXPRESSION ?] ;
               --> := EXPRESSION
               --> NAME  IDENTIFIER_TAIL

(3.3.2) (parser3)
CONSTRAINT    --> range RANGES
              --> digits FLOATING_OR_FIXED_POINT_CONSTRAINT
              --> delta FLOATING_OR_FIXED_POINT_CONSTRAINT
              --> (INDEX_CONSTRAINT

(10.1.1) (parser1)
CONTEXT_CLAUSE --> [ with WITH_OR_USE_CLAUSE [ use WITH_OR_USE_CLAUSE]*]*

(3.9) (parser1)
DECLARATIVE_PART --> [ BASIC_DECLARATIVE_ITEM]* [ LATER_DECLARATIVE_ITEM]*

(9.6) (parser3)
DELAY_STATEMENT --> SIMPLE_EXPRESSION ;

(6.1) (parser2)
DESIGNATOR    --> identifier
              --> string_literal

(3.6) (parser3)
DISCRETE_RANGE --> RANGES [ CONSTRAINT ?]

(3.7.1) (parser2)
DISCRIMINANT_PART --> (DISCRIMINANT_SPECIFICATION [ ; DISCRIMINANT_SPECIFICATION]* )

(3.7.1) (parser2)
DISCRIMINANT_SPECIFICATION --> IDENTIFIER_LIST : NAME [ := EXPRESSION ?]
```

```
(9.5) (parser2)
ENTRY_DECLARATION -->  entry identifier [ (DISCRETE_RANGE) ?] [ FORMAL_PART ?] ;

(3.5.1) (parser4)
ENUMERATION_LITERAL  -->  identifier
                     -->  character_literal

(3.5.1) (parser4)
ENUMERATION_TYPE_DEFINITION -->  (ENUMERATION_LITERAL [ , ENUMERATION_LITERAL]* )

(11.1) (parser2)
EXCEPTION_CHOICE  -->  identifier
                  -->  others

(11.2) (parser1)
EXCEPTION_HANDLER -->  when EXCEPTION_CHOICE [ | EXCEPTION_CHOICE]*
                          =>  SEQUENCE_OF_STATEMENTS

(8.5) (parser2)
EXCEPTION_TAIL -->  ;
               -->  renames NAME ;

(5.7) (parser3)
EXIT_STATEMENT -->  [ NAME ?] [ when EXPRESSION ?] ;

(4.4) (parser3)
EXPRESSION -->  RELATION  RELATION_TAIL

(4.4) (parser3)
FACTOR   -->  PRIMARY [ ** PRIMARY ?]
         -->  abs PRIMARY
         -->  not PRIMARY

(3.5.7) (parser3)
FLOATING_OR_FIXED_POINT_CONSTRAINT -->  SIMPLE_EXPRESSION [ range RANGES ?]

(6.4) (parser4)
FORMAL_PARAMETER -->  identifier =>

(6.1) (parser2)
FORMAL_PART -->  (PARAMETER_SPECIFICATION [ ; PARAMETER_SPECIFICATION]* )

(6.1) (parser1)
FUNCTION_BODY  -->  is [ FUNCTION_BODY_TAIL ?]
               -->  ;

(6.1) (parser1)
FUNCTION_BODY_TAIL   -->  separate ;
                     -->  <> ;
                     -->  SUBPROGRAM_BODY
                     -->  NAME ;

(6.1) (parser1)
FUNCTION_UNIT -->  DESIGNATOR  FUNCTION_UNIT_TAIL

(6.1) (parser1)
FUNCTION_UNIT_TAIL   -->  is new NAME [ GENERIC_ACTUAL_PART ?] ;
                     -->  [ FORMAL_PART ?]  return NAME  FUNCTION_BODY

(12.1) (parser2)
GENERIC_ACTUAL_PART -->  (GENERIC_ASSOCIATION [ , GENERIC_ASSOCIATION]* )

(12.1) (parser2)
GENERIC_ASSOCIATION --> [ GENERIC_FORMAL_PARAMETER ?]  EXPRESSION

(12.1) (parser1)
GENERIC_DECLARATION --> [ GENERIC_PARAMETER_DECLARATION ?]  GENERIC_FORMAL_PART
```

```
(12.1) (parser2)
GENERIC_FORMAL_PARAMETER    -->  identifier =>
                            -->  string_literal =>

(12.1) (parser1)
GENERIC_FORMAL_PART   -->  procedure PROCEDURE_UNIT
                      -->  function FUNCTION_UNIT
                      -->  package PACKAGE_DECLARATION

(12.1) (parser1)
GENERIC_PARAMETER_DECLARATION -->  IDENTIFIER_LIST : [ MODE ?] NAME [ := EXPRESSION ?] ;
                              -->  type private [ DISCRIMINANT_PART ?] is
                                    PRIVATE_TYPE_DECLARATION ;
                              -->  type private [ DISCRIMINANT_PART ?] is
                                    GENERIC_TYPE_DEFINITION ;
                              -->  with procedure PROCEDURE_UNIT
                              -->  with function FUNCTION_UNIT

(12.1) (parser2)
GENERIC_TYPE_DEFINITION -->  ( <> )
                        -->  range <>
                        -->  digits <>
                        -->  delta <>
                        -->  array ARRAY_TYPE_DEFINITION
                        -->  access SUBTYPE_DEFINITION

(5.9) (parser3)
GOTO_STATEMENT -->  NAME ;

(3.2) (parser2)
IDENTIFIER_DECLARATION -->  IDENTIFIER_LIST : IDENTIFIER_DECLARATION_TAIL

(3.2) (parser2)
IDENTIFIER_DECLARATION_TAIL   -->  exception EXCEPTION_TAIL
                              -->  constant CONSTANT_TERM
                              -->  array CONSTRAINED_ARRAY_DEFINITION
                                   [ := EXPRESSION ?]  ;
                              -->  NAME  IDENTIFIER_TAIL

(3.2) (parser2)
IDENTIFIER_LIST -->  identifier [ , identifier]*

(3.2) (parser2)
IDENTIFIER_TAIL    -->  [ CONSTRAINT ?] [ := EXPRESSION ?]  ;
                   -->  [ renames NAME ?]  ;

(5.3) (parser1)
IF_STATEMENT -->  EXPRESSION then SEQUENCE_OF_STATEMENTS
                [ elsif EXPRESSION then SEQUENCE_OF_STATEMENTS]* [ else
                  SEQUENCE_OF_STATEMENTS ?]  end if ;

(3.6) (parser3)
INDEX_CONSTRAINT -->  DISCRETE_RANGE [ , DISCRETE_RANGE]*  )

(3.5.4) (parser3)
INTEGER_TYPE_DEFINITION -->  range RANGES

(5.5) (parser3)
ITERATION_SCHEME   -->  while EXPRESSION
                   -->  for LOOP_PARAMETER_SPECIFICATION

(5.1) (parser2)
LABEL -->  << identifier >>

(3.9) (parser1)
LATER_DECLARATIVE_ITEM  -->  PROPER_BODY
                        -->  generic GENERIC_DECLARATION
                        -->  use WITH_OR_USE_CLAUSE
```

```
(4.1) (parser3)
LEFT_PAREN_NAME_TAIL -->  [ FORMAL_PARAMETER ?] EXPRESSION [ ..EXPRESSION ?]
                          [ , [ FORMAL_PARAMETER ?] [ , EXPRESSION [ ..EXPRESSION ?]]* ) [
                          NAME_TAIL]*
                     -->  DISCRETE_RANGE ) [ NAME_TAIL]*

(10.1) (parser0)
LIBRARY_UNIT     -->  procedure PROCEDURE_UNIT
                 -->  function FUNCTION_UNIT
                 -->  package PACKAGE_DECLARATION
                 -->  generic GENERIC_DECLARATION

(10.1) (parser0)
LIBRARY_UNIT_BODY -->  procedure PROCEDURE_UNIT
                  -->  function FUNCTION_UNIT
                  -->  package PACKAGE_DECLARATION
                  -->  generic GENERIC_DECLARATION

(5.5) (parser3)
LOOP_PARAMETER_SPECIFICATION -->  identifier in [ reverse ?] DISCRETE_RANGE

(5.5) (parser1)
LOOP_STATEMENT -->  [ identifier : ?] [ ITERATION_SCHEME ?] loop
                    SEQUENCE_OF_STATEMENTS end loop [ identifier ?] ;

(6.1) (parser2)
MODE  -->  [ in ?]
      -->  in out
      -->  out

(4.5) (parser4)
MULTIPLYING_OPERATOR -->  *
                     -->  /
                     -->  mod
                     -->  rem

(4.1) (parser3)
NAME  -->  identifier [ NAME_TAIL ?]
      -->  character_literal [ NAME_TAIL ?]
      -->  string_literal [ NAME_TAIL ?]

(4.1) (parser3)
NAME_TAIL   -->  (LEFT_PAREN_NAME_TAIL
            -->  .SELECTOR [ NAME_TAIL]*
            -->  'AGGREGATE [ NAME_TAIL]*
            -->  'ATTRIBUTE_DESIGNATOR [ NAME_TAIL]*

(7.1) (parser1)
PACKAGE_BODY -->  identifier is PACKAGE_BODY_TAIL

(7.1) (parser1)
PACKAGE_BODY_TAIL -->  separate ;
                  -->  [ DECLARATIVE_PART ?] [ begin SEQUENCE_OF_STATEMENTS
                       [ exception [ EXCEPTION_HANDLER]* ?] ?] end [ identifier ?] ;

(7.1) (parser1)
PACKAGE_TAIL_END  -->  new NAME [ GENERIC_ACTUAL_PART ?] ;
                  -->  [ BASIC_DECLARATIVE_ITEM]* [ private
                       [ BASIC_DECLARATIVE_ITEM]* ?] end [ identifier ?] ;

(7.1) (parser1)
PACKAGE_DECLARATION  -->  body PACKAGE_BODY
                     -->  identifier PACKAGE_UNIT

(7.1) (parser1)
PACKAGE_UNIT   -->  is PACKAGE_TAIL_END
               -->  renames NAME ;
```

```
(6.1) (parser2)
PARAMETER_SPECIFICATION -->  IDENTIFIER_LIST : MODE  NAME [ := EXPRESSION ?]

(4.4) (parser3)
PRIMARY  -->  numeric_literal
         -->  null
         -->  string_literal
         -->  new ALLOCATOR
         -->  NAME
         -->  AGGREGATE

(7.4) (parser2)
PRIVATE_TYPE_DECLARATION --> [ limited ?]  private

(6.1) (parser1)
PROCEDURE_UNIT -->  identifier [ FORMAL_PART ?]  is SUBPROGRAM_BODY
               -->  identifier [ FORMAL_PART ?]  ;
               -->  identifier [ FORMAL_PART ?]  renames NAME ;

(3.9) (parser1)
PROPER_BODY -->  procedure PROCEDURE_UNIT
            -->  function FUNCTION_UNIT
            -->  package PACKAGE_DECLARATION
            -->  task TASK_DECLARATION

(3.5) (parser3)
RANGES -->  SIMPLE_EXPRESSION [ ..SIMPLE_EXPRESSION ?]

(11.3) (parser3)
RAISE_STATEMENT --> [ NAME ?] ;

(13.4) (parser2)
RECORD_REPRESENTATION_CLAUSE --> [ at mod SIMPLE_EXPRESSION ?]
                                 [ NAME at SIMPLE_EXPRESSION range RANGES]*
                                 end record ;

(3.7) (parser2)
RECORD_TYPE_DEFINITION -->  COMPONENT_LIST end record

(4.4) (parser3)
RELATION -->  SIMPLE_EXPRESSION [ SIMPLE_EXPRESSION_TAIL ?]

(4.4) (parser3)
RELATION_TAIL  -->  [ and [ then ?]  RELATION]*
               -->  [ or [ else ?]  RELATION]*
               -->  [ xor RELATION]*

(4.5) (parser4)
RELATIONAL_OPERATOR  -->  =
                     -->  /=
                     -->  <
                     -->  <=
                     -->  >
                     -->  >=

(13.1) (parser2)
REPRESENTATION_CLAUSE   -->  for NAME use record RECORD_REPRESENTATION_CLAUSE
                        -->  for NAME use [ at ?]  SIMPLE_EXPRESSION ;

(5.8) (parser3)
RETURN_STATEMENT --> [ EXPRESSION ?]  ;

(10.1) (parser0)
SECONDARY_UNIT -->  LIBRARY_UNIT_BODY
               -->  SUBUNIT
```

```
(9.7.1) (parser1)
SELECT_ALTERNATIVE     --> [ when EXPRESSION => ?] accept ACCEPT_STATEMENT
                           [ SEQUENCE_OF_STATEMENTS ?]
                       --> [ when EXPRESSION => ?] delay DELAY_STATEMENT
                           [ SEQUENCE_OF_STATEMENTS ?]
                       --> [ when EXPRESSION => ?] terminate ;

(9.7.1) (parser1)
SELECT_ENTRY_CALL --> else SEQUENCE_OF_STATEMENTS
                  --> or delay DELAY_STATEMENT [ SEQUENCE_OF_STATEMENTS ?]

(9.7) (parser1)
SELECT_STATEMENT --> SELECT_STATEMENT_TAIL  SELECT_ENTRY_CALL  and select ;

(9.7.1) (parser1)
SELECT_STATEMENT_TAIL   --> SELECT_ALTERNATIVE [ or SELECT_ALTERNATIVE]*
                        --> NAME ; [ SEQUENCE_OF_STATEMENTS ?]

(4.1.3) (parser4)
SELECTOR --> identifier
         --> character_literal
         --> string_literal
         --> all

(5.1) (parser1)
SEQUENCE_OF_STATEMENTS --> [ STATEMENT]+

(4.4) (parser3)
SIMPLE_EXPRESSION --> [ + ?] TERM [ BINARY_ADDING_OPERATOR  TERM]*
                  --> [ - ?] TERM [ BINARY_ADDING_OPERATOR  TERM]*

(4.4) (parser3)
SIMPLE_EXPRESSION_TAIL  --> RELATIONAL_OPERATOR  SIMPLE_EXPRESSION
                        --> [ not ?]  in RANGES
                        --> [ not ?]  in NAME

(5.1) (parser2)
SIMPLE_STATEMENT  --> null ;
                  --> ASSIGNMENT_STATEMENT
                  --> PROCEDURE_CALL_STATEMENT
                  --> exit EXIT_STATEMENT
                  --> return RETURN_STATEMENT
                  --> goto GOTO_STATEMENT
                  --> delay DELAY_STATEMENT
                  --> abort ABORT_STATEMENT
                  --> raise RAISE_STATEMENT
                  --> ENTRY_CALL_STATEMENT
                  --> CODE_STATEMENT

(5.1) (parser1)
STATEMENT    --> [ LABEL ?]  SIMPLE_STATEMENT
             --> [ LABEL ?]  COMPOUND_STATEMENT

(6.3) (parser1)
SUBPROGRAM_BODY   --> new NAME [ GENERIC_ACTUAL_PART ?]  ;
                  --> separate ;
                  --> <> ;
                  --> [ DECLARATIVE_PART ?]  begin SEQUENCE_OF_STATEMENTS
                      [ exception [ EXCEPTION_HANDLER]+ ?]
                        end [ DESIGNATOR ?]  ;
                  --> NAME ;

(3.3.2) (parser2)
SUBTYPE_DECLARATION --> identifier is SUBTYPE_INDICATION ;

(3.3.2) (parser3)
SUBTYPE_INDICATION --> NAME [ CONSTRAINT ?]
```

```
(10.2) (parser0)
SUBUNIT -->  separate (NAME) PROPER_BODY

(9.1) (parser1)
TASK_BODY -->  identifier is TASK_BODY_TAIL

(9.1) (parser1)
TASK_BODY_TAIL -->  separate
               -->  [ DECLARATIVE_PART ?]  begin SEQUENCE_OF_STATEMENTS
                    [ exception [ EXCEPTION_HANDLER]+ ?]
                     end [ identifier ?]

(9.1) (parser1)
TASK_DECLARATION  -->  body TASK_BODY ;
                  -->  [ type ?]  identifier [ is [ ENTRY_DECLARATION]*
                        [ REPRESENTATION_CLAUSE]*  end [ identifier ?] ?] ;

(4.4) (parser3)
TERM -->  FACTOR [ MULTIPLYING_OPERATOR  FACTOR]*

(3.3.1) (parser2)
TYPE_DECLARATION  -->  identifier [ DISCRIMINANT_PART ?]
                       [ is PRIVATE_TYPE_DEFINITION ?]  ;
                  -->  identifier [ DISCRIMINANT_PART ?]
                       [ is TYPE_DEFINITION ?]  ;

(3.3.1) (parser2)
TYPE_DEFINITION   -->  ENUMERATION_TYPE_DEFINITION
                  -->  INTEGER_TYPE_DEFINITION
                  -->  digits FLOATING_OR_FIXED_POINT_CONSTRAINT
                  -->  delta FLOATING_OR_FIXED_POINT_CONSTRAINT
                  -->  array ARRAY_TYPE_DEFINITION
                  -->  record RECORD_TYPE_DEFINITION
                  -->  access SUBTYPE_DEFINITION
                  -->  new SUBTYPE_INDICATION

(3.7.3) (parser2)
VARIANT -->  when CHOICE [ | CHOICE]* =>  COMPONENT_LIST

(3.7.3) (parser2)
VARIANT_PART -->  case identifier is [ VARIANT]+ end case ;

(10.1.1) (parser2)
WITH_OR_USE_CLAUSE -->  identifier [ , identifier]* ;
```

APPENDIX B

'ADAMEASURE' USERS GUIDE

1. Once you have logged on a VT100 terminal, type RUN DEMON to begin execution of 'AdaMeasure'. The initial screen gives the general information about the program.

```
****************************************************************
*                                                              *
*                    WELCOME TO 'AdaMEASURE'                   *
*                                                              *
*          AUTHORED BY: LCDR JEFFREY L. NIEDER, USN            *
*                       LT   KARL S. FAIRBANKS  , USN          *
*                                                              *
*                  NAVAL POSTGRADUATE SCHOOL                   *
*               DEPARTMENT OF COMPUTER SCIENCE                 *
*                   MONTEREY, CALIFORNIA                       *
*                                                              *
*                      31 OCTOBER 1986                         *
*                                                              *
*                        VERSION 1.0                           *
*                                                              *
* This program provides an automated  software metric  tool  which *
* uses quantitative measures in an effort to supply the user  with *
* helpful information about the static structure of  a given input *
* program.  This program is public domain information.         *
*                                                              *
****************************************************************
               --- Enter any letter to continue ---
```

2. Enter any letter to continue. This is required because Ada filters out carriage returns so just hitting ENTER will not cause execution to continue. The next screen shown is the MAIN SELECTION MENU. From here the user enters the digits 1, 2 or 3 to either parse a file, view previously gathered data, or quit to the operating system, respectively.

```
*************************************************************************
*                                                                       *
*                         MAIN SELECTION MENU                           *
*                                                                       *
*              HERE ARE THE ACTION CHOICES AVAILABLE TO YOU             *
*                                                                       *
*                  Simply enter the number of your choice               *
*                                                                       *
*              1 - PARSE AN INPUT FILE                                  *
*                                                                       *
*              2 - VIEW PREVIOUSLY GATHERED DATA                        *
*                                                                       *
*              3 - EXIT TO OPERATING SYSTEM                             *
*                                                                       *
*************************************************************************
Choice =
```

3. If the user selects number one then he will be prompted for the file name of the file he wishes to have parsed. While parsing of the file is in progress, the user will see a message on the screen indicating at what line number, in the input file, the parser has

reached. When parsing of the input file commences, 'AdaMeasure' creates four new files. The four files have the same name as the user's input file with the following extensions: fn.DATA, fn.HALS, fn.RAND, fn.MISC. The meaning of each of these new files will be explained later in this user's guide.

4. Upon conclusion of parsing the input file, or if the user selects number two from the MAIN SELECTION MENU, the program displays the METRIC SELECTION PROGRAM. From this menu, the user can select any of the listed metrics, exit to the MAIN SELECTION MENU, or exit to the operating system.

```
*************************************************************************
*                                                                       *
*                        METRIC SELECTION MENU                          *
*                                                                       *
*           HERE ARE THE INFORMATION CHOICES AVAILABLE TO YOU           *
*                                                                       *
*               Simply enter the number of your choice                  *
*                                                                       *
*           1 - 'HALSTEAD' METRIC INFORMATION                           *
*                                                                       *
*           2 - COMMENT AND NESTING METRIC INFORMATION                  *
*                                                                       *
*           3 - 'HENRY and KAFURA' METRIC INFORMATION                   *
*                                                                       *
*           4 - EXIT TO MAIN MENU                                       *
*                                                                       *
*           5 - EXIT TO OPERATING SYSTEM                                *
*                                                                       *
*************************************************************************
Choice =
```

5. If number one is selected, the Halstead Metric choice, the next menu displayed is the HALSTEAD SELECTION MENU. From this menu, the calculations and conclusions of the Halstead Metric can be selected. There also exists the options of exiting to the METRIC SELECTION MENU, or exiting to the operating system.

```
*************************************************************************
*                                                                       *
*                        HALSTEAD SELECTION MENU                        *
*                                                                       *
*                                                                       *
*         HERE ARE THE HALSTEAD METRIC OPTIONS AVAILABLE TO YOU         *
*                                                                       *
*               Simply enter the number of your choice                  *
*                                                                       *
*           1 - HALSTEAD OPERATORS                                      *
*                                                                       *
*           2 - HALSTEAD OPERANDS                                       *
*                                                                       *
*           3 - HALSTEAD METRIC CONCLUSIONS                             *
*                                                                       *
*           4 - EXIT TO METRIC SELECTION MENU                           *
*                                                                       *
*           5 - EXIT TO OPERATING SYSTEM                                *
*                                                                       *
*************************************************************************
Choice =
```

6. From the HALSTEAD SELECTION MENU, if number one is selected, the Halstead operator data is displayed. The operator data is stored in the fn.DATA file. The Halstead operator data includes the total number of different operators used, the total number of occurences of those operators, and the number of occurences of each individual operator.

7. If number two from the HALSTEAD SELECTION MENU is chosen, the HALSTEAD OPERAND SELECTION MENU is displayed. From this menu the different classes of operands and their data can be selected for viewing. Also available for selection are exiting to the HALSTEAD SELECTION MENU, and exiting to the operating system.

```
*****************************************************************************
*                                                                           *
*                      HALSTEAD OPERAND SELECTION MENU                      *
*                                                                           *
*                                                                           *
*                     HERE IS THE OPERAND DATA AVAILABLE                    *
*                                                                           *
*                    Simply enter the number of your choice                 *
*                                                                           *
*            1 - PROCEDURE, FUNCTION, PACKAGE INFORMATION                   *
*                                                                           *
*            2 - VARIABLES AND CONSTANTS INFORMATION                        *
*                                                                           *
*            3 - TASKS AND BLOCKS INFORMATION                               *
*                                                                           *
*            4 - EXIT TO HALSTEAD SELECTION MENU                            *
*                                                                           *
*            5 - EXIT TO OPERATING SYSTEM                                   *
*                                                                           *
*****************************************************************************
Choice =
```

8. From the HALSTEAD OPERAND SELECTION MENU, selection of any of the operand calasses will show each identifier and number of occurences of for that particular class. The data for all operand classes is stored in the fn.RAND file.

9. Back to the HALSTEAD SELECTION MENU. If the selection is number three, the Halstead Metric conclusions are displayed. The conclusions include the input file's calculated theoritical length, its actual length, the difference between the two lengths, and some comments about that difference. The Halstead Metric conclusion data is stored in the fn.HALS file.

10. Back to the METRIC SELECTION MENU. If the selection number is two, the comment and nesting metric information is displayed on the screen. The comment metric information includes the total number of lines in the input file, the total number

of comment lines, a percentage of lines of comments to lines of code, and some observations about that percentage. The nesting metric information contains the type and total occurences of nesting contructs used in the input file, the deepest level of nesting parsed, and how many times each nesting level, up to the deepest, was encountered. The comment and nesting metric information is stored in the fn.MISC file.

11. The final choice in the METRIC SELECTION MENU is the Henry and Kafura Complexity Flow Metric. At present, this metric is not implemented. Ongoing development of 'AdaMeasure' includes plans to implement this metric as well as other metrics and Ada tools.

APPENDIX C

'ADAMEASURE' PROGRAM LISTING - PART 1

```
--*******************************************************--
--                                                       --
--  TITLE:          AN ADA SOFTWARE METRIC               --
--                                                       --
--  MODULE NAME:    PACKAGE BYPASS_FUNCTION              --
--  DATE CREATED:   25 JUL 86                            --
--  LAST MODIFIED:  03 DEC 86                            --
--                                                       --
--  AUTHORS:        LCDR JEFFREY L. NIEDER               --
--                  LT KARL S. FAIRBANKS, JR.            --
--                                                       --
--  DESCRIPTION:  This package contains the workhorse function  --
--       required to identify each individual token.     --
--                                                       --
--*******************************************************--

with HALSTEAD_METRIC, BYPASS_SUPPORT_FUNCTIONS, GLOBAL, GLOBAL_PARSER;
use HALSTEAD_METRIC, BYPASS_SUPPORT_FUNCTIONS, GLOBAL, GLOBAL_PARSER;

package BYPASS_FUNCTION is
   function BYPASS(TOKEN_ARRAY_ENTRY_CODE : integer) return boolean;
   procedure CONDUCT_RESERVE_WORD_TEST(CONSUME : in out boolean);
end BYPASS_FUNCTION;

--------------------------------------------------------------------------------
--------------------------------------------------------------------------------

package body BYPASS_FUNCTION is

   -- this function compares the lexeme of the current token with the
   --  token currently being sought by the parser.  If the current token
   --  type is identifier, then a test is conducted to ensure it is not
   --  a reserved word.
function BYPASS(TOKEN_ARRAY_ENTRY_CODE : integer) return boolean is
   CONSUME        : boolean := FALSE;
   LEXEME         : string(1..LINESIZE);
   SIZE           : natural;
begin
   GET_CURRENT_TOKEN_RECORD(CURRENT_TOKEN_RECORD, LEXEME_LENGTH);
   LEXEME := CURRENT_TOKEN_RECORD.LEXEME;
   SIZE := CURRENT_TOKEN_RECORD.LEXEME_SIZE - 1;

   case TOKEN_ARRAY_ENTRY_CODE is
      when TOKEN_IDENTIFIER =>
            if (CURRENT_TOKEN_RECORD.TOKEN_TYPE = IDENTIFIER) then
               CONSUME := TRUE;
               CONDUCT_RESERVE_WORD_TEST(CONSUME);
            end if;
            if (CONSUME) then
               CONVERT_UPPER_CASE(LEXEME, SIZE);
               OPERAND_METRIC(HEAD_NODE, CURRENT_TOKEN_RECORD, DECLARE_TYPE);
               DECLARE_TYPE := VARIABLE_DECLARE;
            end if;

      when TOKEN_NUMERIC_LITERAL =>
            if (CURRENT_TOKEN_RECORD.TOKEN_TYPE = NUMERIC_LIT) then
               CONSUME := TRUE;
               DECLARE_TYPE := CONSTANT_DECLARE;
               OPERAND_METRIC(HEAD_NODE, CURRENT_TOKEN_RECORD, DECLARE_TYPE);
               DECLARE_TYPE := VARIABLE_DECLARE;
            end if;
```

```
when TOKEN_CHARACTER_LITERAL =>
      if (CURRENT_TOKEN_RECORD.TOKEN_TYPE = CHARACTER_LIT) then
         CONSUME := TRUE;
      end if;

when TOKEN_STRING_LITERAL =>
      if (CURRENT_TOKEN_RECORD.TOKEN_TYPE = STRING_LIT) then
         CONSUME := TRUE;
      end if;

when TOKEN_END =>
      if (ADJUST_LEXEME(LEXEME, SIZE) = "end") then
         CONSUME := TRUE;
      end if;

when TOKEN_BEGIN =>
      if (ADJUST_LEXEME(LEXEME, SIZE) = "begin") then
         CONSUME := TRUE;
      end if;

when TOKEN_IF =>
      if (ADJUST_LEXEME(LEXEME, SIZE) = "if") then
         CONSUME := TRUE;
      end if;

when TOKEN_THEN =>
      if (ADJUST_LEXEME(LEXEME, SIZE) = "then") then
         CONSUME := TRUE;
      end if;

when TOKEN_ELSIF =>
      if (ADJUST_LEXEME(LEXEME, SIZE) = "elsif") then
         CONSUME := TRUE;
      end if;

when TOKEN_ELSE =>
      if (ADJUST_LEXEME(LEXEME, SIZE) = "else") then
         CONSUME := TRUE;
      end if;

when TOKEN_WHILE =>
      if (ADJUST_LEXEME(LEXEME, SIZE) = "while") then
         CONSUME := TRUE;
      end if;

when TOKEN_LOOP =>
      if (ADJUST_LEXEME(LEXEME, SIZE) = "loop") then
         CONSUME := TRUE;
      end if;

when TOKEN_CASE =>
      if (ADJUST_LEXEME(LEXEME, SIZE) = "case") then
         CONSUME := TRUE;
      end if;

when TOKEN_WHEN =>
      if (ADJUST_LEXEME(LEXEME, SIZE) = "when") then
         CONSUME := TRUE;
      end if;

when TOKEN_DECLARE =>
      if (ADJUST_LEXEME(LEXEME, SIZE) = "declare") then
         CONSUME := TRUE;
      end if;

when TOKEN_FOR =>
      if (ADJUST_LEXEME(LEXEME, SIZE) = "for") then
         CONSUME := TRUE;
```

```
      end if;

   when TOKEN_OTHERS =>
      if (ADJUST_LEXEME(LEXEME, SIZE) = "others") then
         CONSUME := TRUE;
      end if;

   when TOKEN_RETURN =>
      if (ADJUST_LEXEME(LEXEME, SIZE) = "return") then
         CONSUME := TRUE;
      end if;

   when TOKEN_EXIT =>
      if (ADJUST_LEXEME(LEXEME, SIZE) = "exit") then
         CONSUME := TRUE;
      end if;

   when TOKEN_PROCEDURE =>
      if (ADJUST_LEXEME(LEXEME, SIZE) = "procedure") then
         CONSUME := TRUE;
      end if;

   when TOKEN_FUNCTION =>
      if (ADJUST_LEXEME(LEXEME, SIZE) = "function") then
         CONSUME := TRUE;
      end if;

   when TOKEN_WITH =>
      if (ADJUST_LEXEME(LEXEME, SIZE) = "with") then
         CONSUME := TRUE;
      end if;

   when TOKEN_USE =>
      if (ADJUST_LEXEME(LEXEME, SIZE) = "use") then
         CONSUME := TRUE;
      end if;

   when TOKEN_PACKAGE =>
      if (ADJUST_LEXEME(LEXEME, SIZE) = "package") then
         CONSUME := TRUE;
      end if;

   when TOKEN_BODY =>
      if (ADJUST_LEXEME(LEXEME, SIZE) = "body") then
         CONSUME := TRUE;
      end if;

   when TOKEN_RANGE =>
      if (ADJUST_LEXEME(LEXEME, SIZE) = "range") then
         CONSUME := TRUE;
      end if;

   when TOKEN_IN =>
      if (ADJUST_LEXEME(LEXEME, SIZE) = "in") then
         CONSUME := TRUE;
      end if;

   when TOKEN_OUT =>
      if (ADJUST_LEXEME(LEXEME, SIZE) = "out") then
         CONSUME := TRUE;
      end if;

   when TOKEN_SUBTYPE =>
      if (ADJUST_LEXEME(LEXEME, SIZE) = "subtype") then
         CONSUME := TRUE;
      end if;

   when TOKEN_TYPE =>
      if (ADJUST_LEXEME(LEXEME, SIZE) = "type") then
```

```
            CONSUME := TRUE;
         end if;

   when TOKEN_IS =>
         if (ADJUST_LEXEME(LEXEME, SIZE) = "is") then
            CONSUME := TRUE;
         end if;

   when TOKEN_NULL =>
         if (ADJUST_LEXEME(LEXEME, SIZE) = "null") then
            CONSUME := TRUE;
         end if;

   when TOKEN_ACCESS =>
         if (ADJUST_LEXEME(LEXEME, SIZE) = "access") then
            CONSUME := TRUE;
         end if;

   when TOKEN_ARRAY =>
         if (ADJUST_LEXEME(LEXEME, SIZE) = "array") then
            CONSUME := TRUE;
         end if;

   when TOKEN_DIGITS =>
         if (ADJUST_LEXEME(LEXEME, SIZE) = "digits") then
            CONSUME := TRUE;
         end if;

   when TOKEN_DELTA =>
         if (ADJUST_LEXEME(LEXEME, SIZE) = "delta") then
            CONSUME := TRUE;
         end if;

   when TOKEN_RECORD_STRUCTURE =>
         if (ADJUST_LEXEME(LEXEME, SIZE) = "record") then
            CONSUME := TRUE;
         end if;

   when TOKEN_CONSTANT =>
         if (ADJUST_LEXEME(LEXEME, SIZE) = "constant") then
            CONSUME := TRUE;
         end if;

   when TOKEN_NEW =>
         if (ADJUST_LEXEME(LEXEME, SIZE) = "new") then
            CONSUME := TRUE;
         end if;

   when TOKEN_EXCEPTION =>
         if (ADJUST_LEXEME(LEXEME, SIZE) = "exception") then
            CONSUME := TRUE;
         end if;

   when TOKEN_RENAMES =>
         if (ADJUST_LEXEME(LEXEME, SIZE) = "renames") then
            CONSUME := TRUE;
         end if;

   when TOKEN_PRIVATE =>
         if (ADJUST_LEXEME(LEXEME, SIZE) = "private") then
            CONSUME := TRUE;
         end if;

   when TOKEN_LIMITED =>
         if (ADJUST_LEXEME(LEXEME, SIZE) = "limited") then
            CONSUME := TRUE;
         end if;

   when TOKEN_TASK =>
```

```
        if (ADJUST_LEXEME(LEXEME, SIZE) = "task") then
           CONSUME := TRUE;
        end if;

    when TOKEN_ENTRY =>
        if (ADJUST_LEXEME(LEXEME, SIZE) = "entry") then
           CONSUME := TRUE;
        end if;

    when TOKEN_ACCEPT =>
        if (ADJUST_LEXEME(LEXEME, SIZE) = "accept") then
           CONSUME := TRUE;
        end if;

    when TOKEN_DELAY =>
        if (ADJUST_LEXEME(LEXEME, SIZE) = "delay") then
           CONSUME := TRUE;
        end if;

    when TOKEN_SELECT =>
        if (ADJUST_LEXEME(LEXEME, SIZE) = "select") then
           CONSUME := TRUE;
        end if;

    when TOKEN_TERMINATE =>
        if (ADJUST_LEXEME(LEXEME, SIZE) = "terminate") then
           CONSUME := TRUE;
        end if;

    when TOKEN_ABORT =>
        if (ADJUST_LEXEME(LEXEME, SIZE) = "abort") then
           CONSUME := TRUE;
        end if;

    when TOKEN_SEPARATE =>
        if (ADJUST_LEXEME(LEXEME, SIZE) = "separate") then
           CONSUME := TRUE;
        end if;

    when TOKEN_RAISE =>
        if (ADJUST_LEXEME(LEXEME, SIZE) = "raise") then
           CONSUME := TRUE;
        end if;

    when TOKEN_GENERIC =>
        if (ADJUST_LEXEME(LEXEME, SIZE) = "generic") then
           CONSUME := TRUE;
        end if;

    when TOKEN_AT =>
        if (ADJUST_LEXEME(LEXEME, SIZE) = "at") then
           CONSUME := TRUE;
        end if;

    when TOKEN_REVERSE =>
        if (ADJUST_LEXEME(LEXEME, SIZE) = "reverse") then
           CONSUME := TRUE;
        end if;

    when TOKEN_DO =>
        if (ADJUST_LEXEME(LEXEME, SIZE) = "do") then
           CONSUME := TRUE;
        end if;

    when TOKEN_GOTO =>
        if (ADJUST_LEXEME(LEXEME, SIZE) = "goto") then
           CONSUME := TRUE;
        end if;
```

```
when TOKEN_OF =>
      if (ADJUST_LEXEME(LEXEME, SIZE) = "of") then
         CONSUME := TRUE;
      end if;

when TOKEN_ALL =>
      if (ADJUST_LEXEME(LEXEME, SIZE) = "all") then
         CONSUME := TRUE;
      end if;

when TOKEN_PRAGMA =>
      if (ADJUST_LEXEME(LEXEME, SIZE) = "pragma") then
         CONSUME := TRUE;
      end if;

when TOKEN_AND =>
      if (ADJUST_LEXEME(LEXEME, SIZE) = "and") then
         CONSUME := TRUE;
      end if;
      OPERATOR_METRIC(TOKEN_AND, CONSUME, RESERVE_WORD_TEST);

when TOKEN_OR =>
      if (ADJUST_LEXEME(LEXEME, SIZE) = "or") then
         CONSUME := TRUE;
      end if;
      OPERATOR_METRIC(TOKEN_OR, CONSUME, RESERVE_WORD_TEST);

when TOKEN_NOT =>
      if (ADJUST_LEXEME(LEXEME, SIZE) = "not") then
         CONSUME := TRUE;
      end if;
      OPERATOR_METRIC(TOKEN_NOT, CONSUME, RESERVE_WORD_TEST);

when TOKEN_XOR =>
      if (ADJUST_LEXEME(LEXEME, SIZE) = "xor") then
         CONSUME := TRUE;
      end if;
      OPERATOR_METRIC(TOKEN_XOR, CONSUME, RESERVE_WORD_TEST);

when TOKEN_MOD =>
      if (ADJUST_LEXEME(LEXEME, SIZE) = "mod") then
         CONSUME := TRUE;
      end if;
      OPERATOR_METRIC(TOKEN_MOD, CONSUME, RESERVE_WORD_TEST);

when TOKEN_REM =>
      if (ADJUST_LEXEME(LEXEME, SIZE) = "rem") then
         CONSUME := TRUE;
      end if;
      OPERATOR_METRIC(TOKEN_REM, CONSUME, RESERVE_WORD_TEST);

when TOKEN_ABSOLUTE =>
      if (ADJUST_LEXEME(LEXEME, SIZE) = "abs") then
         CONSUME := TRUE;
      end if;
      OPERATOR_METRIC(TOKEN_ABSOLUTE, CONSUME, RESERVE_WORD_TEST);

when TOKEN_ASTERISK =>
      if (ADJUST_LEXEME(LEXEME, SIZE) = "*") then
         CONSUME := TRUE;
      end if;
      OPERATOR_METRIC(TOKEN_ASTERISK, CONSUME, RESERVE_WORD_TEST);

when TOKEN_SLASH =>
      if (ADJUST_LEXEME(LEXEME, SIZE) = "/") then
         CONSUME := TRUE;
      end if;
      OPERATOR_METRIC(TOKEN_SLASH, CONSUME, RESERVE_WORD_TEST);
```

```
when TOKEN_EXPONENT =>
      if (ADJUST_LEXEME(LEXEME, SIZE) = "**") then
         CONSUME := TRUE;
      end if;
      OPERATOR_METRIC(TOKEN_EXPONENT, CONSUME, RESERVE_WORD_TEST);

when TOKEN_PLUS =>
      if (ADJUST_LEXEME(LEXEME, SIZE) = "+") then
         CONSUME := TRUE;
      end if;
      OPERATOR_METRIC(TOKEN_PLUS, CONSUME, RESERVE_WORD_TEST);

when TOKEN_MINUS =>
      if (ADJUST_LEXEME(LEXEME, SIZE) = "-") then
         CONSUME := TRUE;
      end if;
      OPERATOR_METRIC(TOKEN_MINUS, CONSUME, RESERVE_WORD_TEST);

when TOKEN_AMPERSAND =>
      if (ADJUST_LEXEME(LEXEME, SIZE) = "&") then
         CONSUME := TRUE;
      end if;
      OPERATOR_METRIC(TOKEN_AMPERSAND, CONSUME, RESERVE_WORD_TEST);

when TOKEN_EQUALS =>
      if (ADJUST_LEXEME(LEXEME, SIZE) = "=") then
         CONSUME := TRUE;
      end if;
      OPERATOR_METRIC(TOKEN_EQUALS, CONSUME, RESERVE_WORD_TEST);

when TOKEN_NOT_EQUALS =>
      if (ADJUST_LEXEME(LEXEME, SIZE) = "/=") then
         CONSUME := TRUE;
      end if;
      OPERATOR_METRIC(TOKEN_NOT_EQUALS, CONSUME, RESERVE_WORD_TEST);

when TOKEN_LESS_THAN =>
      if (ADJUST_LEXEME(LEXEME, SIZE) = "<") then
         CONSUME := TRUE;
      end if;
      OPERATOR_METRIC(TOKEN_LESS_THAN, CONSUME, RESERVE_WORD_TEST);

when TOKEN_LESS_THAN_EQUALS =>
      if (ADJUST_LEXEME(LEXEME, SIZE) = "<=") then
         CONSUME := TRUE;
      end if;
      OPERATOR_METRIC(TOKEN_LESS_THAN_EQUALS, CONSUME, RESERVE_WORD_TEST);

when TOKEN_GREATER_THAN =>
      if (ADJUST_LEXEME(LEXEME, SIZE) = ">") then
         CONSUME := TRUE;
      end if;
      OPERATOR_METRIC(TOKEN_GREATER_THAN, CONSUME, RESERVE_WORD_TEST);

when TOKEN_GREATER_THAN_EQUALS =>
      if (ADJUST_LEXEME(LEXEME, SIZE) = ">=") then
         CONSUME := TRUE;
      end if;
      OPERATOR_METRIC(TOKEN_GREATER_THAN_EQUALS, CONSUME, RESERVE_WORD_TEST);

when TOKEN_ASSIGNMENT =>
      if (ADJUST_LEXEME(LEXEME, SIZE) = ":=") then
         CONSUME := TRUE;
      end if;
      OPERATOR_METRIC(TOKEN_ASSIGNMENT, CONSUME, RESERVE_WORD_TEST);

when TOKEN_COMMA =>
      if (ADJUST_LEXEME(LEXEME, SIZE) = ",") then
         CONSUME := TRUE;
```

```
          end if;

        when TOKEN_SEMICOLON =>
          if (ADJUST_LEXEME(LEXEME, SIZE) = ";") then
             CONSUME := TRUE;
          end if;

        when TOKEN_PERIOD =>
          if (ADJUST_LEXEME(LEXEME, SIZE) = ".") then
             CONSUME := TRUE;
          end if;

        when TOKEN_LEFT_PAREN =>
          if (ADJUST_LEXEME(LEXEME, SIZE) = "(") then
             CONSUME := TRUE;
          end if;

        when TOKEN_RIGHT_PAREN =>
          if (ADJUST_LEXEME(LEXEME, SIZE) = ")") then
             CONSUME := TRUE;
          end if;

        when TOKEN_COLON =>
          if (ADJUST_LEXEME(LEXEME, SIZE) = ":") then
             CONSUME := TRUE;
          end if;

        when TOKEN_APOSTROPHE =>
          if (ADJUST_LEXEME(LEXEME, SIZE) = "'") then
             CONSUME := TRUE;
          end if;

        when TOKEN_RANGE_DOTS =>
          if (ADJUST_LEXEME(LEXEME, SIZE) = "..") then
             CONSUME := TRUE;
          end if;

        when TOKEN_ARROW =>
          if (ADJUST_LEXEME(LEXEME, SIZE) = "=>") then
             CONSUME := TRUE;
          end if;

        when TOKEN_BAR =>
          if (ADJUST_LEXEME(LEXEME, SIZE) = " ") then
             CONSUME := TRUE;
          end if;

        when TOKEN_BRACKETS =>
          if (ADJUST_LEXEME(LEXEME, SIZE) = "<>") then
             CONSUME := TRUE;
          end if;

        when TOKEN_LEFT_BRACKET =>
          if (ADJUST_LEXEME(LEXEME, SIZE) = "<<") then
             CONSUME := TRUE;
          end if;

        when TOKEN_RIGHT_BRACKET =>
          if (ADJUST_LEXEME(LEXEME, SIZE) = ">>") then
             CONSUME := TRUE;
          end if;

        when others => null;
      end case;

      ADJUST_TOKEN_BUFFER(CONSUME, RESERVE_WORD_TEST);

      return (CONSUME);
   end BYPASS;
```

```
------------------------------------------------------------------------------

   -- this procedure tests all identifiers to verify they are not reserved
   --  words.  The most common reserved words are tested first and the process
   --  halts when a match is made or the test fails.
procedure CONDUCT_RESERVE_WORD_TEST(CONSUME : in out boolean) is
begin
   RESERVE_WORD_TEST := TRUE;
   for RESERVE_WORD_INDEX in TOKEN_END..TOKEN_ABSOLUTE loop
      if (BYPASS(RESERVE_WORD_INDEX)) then
         CONSUME := FALSE;
      end if;
      exit when not CONSUME;
   end loop;
   RESERVE_WORD_TEST := FALSE;
end CONDUCT_RESERVE_WORD_TEST;

end BYPASS_FUNCTION;
```

```
--*********************************************************************--
--                                                                     --
--   TITLE:          AN ADA SOFTWARE METRIC                            --
--                                                                     --
--   MODULE NAME:    PACKAGE BYPASS_SUPPORT_FUNCTIONS                  --
--   DATE CREATED:   03 OCT 86                                         --
--   LAST MODIFIED:  03 DEC 86                                         --
--                                                                     --
--   AUTHORS:        LCDR JEFFREY L. NIEDER                            --
--                   LT KARL S. FAIRBANKS, JR.                         --
--                                                                     --
--   DESCRIPTION:  This package contains the procedures and            --
--        function required to support the function BYPASS.            --
--                                                                     --
--*********************************************************************--

with SCANNER, GLOBAL, GLOBAL_PARSER, TEXT_IO;
use SCANNER, GLOBAL, GLOBAL_PARSER, TEXT_IO;

package BYPASS_SUPPORT_FUNCTIONS is
   package NEW_INTEGER_IO is new TEXT_IO.INTEGER_IO(integer);
   use NEW_INTEGER_IO;

   procedure GET_CURRENT_TOKEN_RECORD
                  (CURRENT_TOKEN_RECORD : in out TOKEN_RECORD_TYPE;
                   LEXEME_LENGTH : in out integer);
   procedure TRACE(TRACE_TOKEN : in string;
                          CONSUME, RESERVE_WORD_TEST : in boolean);
   procedure ADJUST_TOKEN_BUFFER(CONSUME, RESERVE_WORD_TEST : in boolean);
   function ADJUST_LEXEME(INPUT_LEXEME : string; SIZE : natural) return string;
   procedure CONVERT_LOWER_CASE(INPUT_LEXEME : in out string;
                                  LENGTH : in out integer);
   procedure CONVERT_UPPER_CASE(INPUT_LEXEME : in out string;
                                  LENGTH : in out integer);
end BYPASS_SUPPORT_FUNCTIONS;

---------------------------------------------------------------------------------
---------------------------------------------------------------------------------

package body BYPASS_SUPPORT_FUNCTIONS is

   -- this procedure handles the loading of the token record buffer, flushes
   --    out comments (while keeping count of them) and separators, and prints
   --    out the current line being parsed to the screen.
procedure GET_CURRENT_TOKEN_RECORD
               (CURRENT_TOKEN_RECORD : in out TOKEN_RECORD_TYPE;
                LEXEME_LENGTH : in out integer) is
   DISPLAY_DELAY : constant integer := 250;
begin
   if (FIRST_TIME_LOAD) then
      while (PLACE_HOLDER_INDEX /= TOKEN_ARRAY_SIZE + 1) loop
         if not (END_OF_FILE(TEST_FILE)) then
            GET_NEXT_TOKEN(TOKEN_RECORD);
            if ((TOKEN_RECORD.TOKEN_TYPE /= SEPARATOR) and
               (TOKEN_RECORD.TOKEN_TYPE /= COMMENT)) then
               TOKEN_RECORD_BUFFER(PLACE_HOLDER_INDEX) := TOKEN_RECORD;
               PLACE_HOLDER_INDEX := PLACE_HOLDER_INDEX + 1;
            elsif (TOKEN_RECORD.TOKEN_TYPE = COMMENT) then
               COMMENT_COUNT := COMMENT_COUNT + 1;
            end if;
         else
            TOKEN_RECORD_BUFFER(PLACE_HOLDER_INDEX).TOKEN_TYPE := ILLEGAL;
            TOKEN_RECORD_BUFFER(PLACE_HOLDER_INDEX).LEXEME_SIZE := 1;
            PLACE_HOLDER_INDEX := PLACE_HOLDER_INDEX + 1;
         end if;
      end loop;
      FIRST_TIME_LOAD := FALSE;
      FULL := TRUE;
      PLACE_HOLDER_INDEX := 1;
```

```
   elsif ((TOKEN_ARRAY_INDEX = 0) and (not (FULL))) then
      TOKEN_RECORD_BUFFER(0) := TOKEN_RECORD_BUFFER(TOKEN_ARRAY_SIZE);
      while (PLACE_HOLDER_INDEX /= TOKEN_ARRAY_SIZE + 1) loop
         if not (END_OF_FILE(TEST_FILE)) then
            GET_NEXT_TOKEN(TOKEN_RECORD);
            if ((TOKEN_RECORD.TOKEN_TYPE /= SEPARATOR) and
               (TOKEN_RECORD.TOKEN_TYPE /= COMMENT)) then
               TOKEN_RECORD_BUFFER(PLACE_HOLDER_INDEX) := TOKEN_RECORD;
               PLACE_HOLDER_INDEX := PLACE_HOLDER_INDEX + 1;
            elsif (TOKEN_RECORD.TOKEN_TYPE = COMMENT) then
               COMMENT_COUNT := COMMENT_COUNT + 1;
            end if;
         else
            TOKEN_RECORD_BUFFER(PLACE_HOLDER_INDEX).TOKEN_TYPE := ILLEGAL;
            TOKEN_RECORD_BUFFER(PLACE_HOLDER_INDEX).LEXEME_SIZE := 1;
            PLACE_HOLDER_INDEX := PLACE_HOLDER_INDEX + 1;
         end if;
      end loop;
      PLACE_HOLDER_INDEX := 1;
      FULL := TRUE;
   end if;

   if not (RESERVE_WORD_TEST) then
      CURRENT_TOKEN_RECORD := TOKEN_RECORD_BUFFER(TOKEN_ARRAY_INDEX);
   end if;

   LEXEME_LENGTH := CURRENT_TOKEN_RECORD.LEXEME_SIZE - 1;
   if (CURRENT_TOKEN_RECORD.TOKEN_TYPE = IDENTIFIER) then
      CONVERT_LOWER_CASE(CURRENT_TOKEN_RECORD.LEXEME, LEXEME_LENGTH);
   end if;

   STATUS_COUNTER := STATUS_COUNTER + 1;
   if (STATUS_COUNTER = DISPLAY_DELAY) then
      new_line;
      CLEARSCREEN;
      CONVERT_UPPER_CASE(DATA_FILE_NAME, DATA_FILE_SIZE);
      put("Parse of "); put(ADJUST_LEXEME(DATA_FILE_NAME, DATA_FILE_SIZE));
      put(" in progress, at line number "); put(TOTAL_LINES_INPUT, 3);
      STATUS_COUNTER := 0;
   end if;
end GET_CURRENT_TOKEN_RECORD;

-----------------------------------------------------------------------------

procedure TRACE(TRACE_TOKEN : in string;
                        CONSUME, RESERVE_WORD_TEST : in boolean) is
begin
   if (CONSUME) and then not (RESERVE_WORD_TEST) then
      put(RESULT_FILE, "Parsed a(n) ");
      put(RESULT_FILE, TRACE_TOKEN);
      new_line(RESULT_FILE);
   end if;
end TRACE;

-----------------------------------------------------------------------------

   -- this procedure adjusts the pointer to the token record buffer.
procedure ADJUST_TOKEN_BUFFER(CONSUME, RESERVE_WORD_TEST : in boolean) is
begin
   if ((CONSUME) and not (RESERVE_WORD_TEST)) then
      TOKEN_ARRAY_INDEX := (TOKEN_ARRAY_INDEX + 1) mod 50;
      if (TOKEN_ARRAY_INDEX = 0) then
         FULL := FALSE;
      end if;
   end if;
end ADJUST_TOKEN_BUFFER;

-----------------------------------------------------------------------------
```

```
   -- this function takes as input the 132 character input_lexeme and generates
   --  a variable length string based on the actual size of the input_lexeme.
function ADJUST_LEXEME(INPUT_LEXEME : string; SIZE : natural) return string is
   subtype LEXEME_BUFFER is string(1..SIZE);
   ADJUSTED_LEXEME : LEXEME_BUFFER;
begin
   for I in 1..SIZE loop
      ADJUSTED_LEXEME(I) := INPUT_LEXEME(I);
   end loop;
   return (ADJUSTED_LEXEME);
end ADJUST_LEXEME;

-------------------------------------------------------------------------------

procedure CONVERT_LOWER_CASE(INPUT_LEXEME : in out string;
                                         LENGTH : in out integer) is
   CONVERSION_FACTOR : constant integer := 32;
         -- difference between upper case and lower case letters in ASCII
   LETTER_VALUE : integer;
begin
   for I in 1..LENGTH loop
      if (INPUT_LEXEME(I) in UPPER_CASE_LETTER) then
         LETTER_VALUE := character'pos(INPUT_LEXEME(I)) + CONVERSION_FACTOR;
         INPUT_LEXEME(I) := character'val(LETTER_VALUE);
      end if;
   end loop;
end CONVERT_LOWER_CASE;

-------------------------------------------------------------------------------

procedure CONVERT_UPPER_CASE(INPUT_LEXEME : in out string;
                                         LENGTH : in out integer) is
   CONVERSION_FACTOR : constant integer := 32;
         -- difference between upper case and lower case letters in ASCII
   LETTER_VALUE : integer;
begin
   for I in 1..LENGTH loop
      if (INPUT_LEXEME(I) in LOWER_CASE_LETTER) then
         LETTER_VALUE := character'pos(INPUT_LEXEME(I)) - CONVERSION_FACTOR;
         INPUT_LEXEME(I) := character'val(LETTER_VALUE);
      end if;
   end loop;
end CONVERT_UPPER_CASE;

end BYPASS_SUPPORT_FUNCTIONS;
```

```
--*************************************************************--
--                                                             --
--  TITLE:          AN ADA SOFTWARE METRIC                     --
--                                                             --
--  MODULE NAME:    PROCEDURE DEMON                            --
--  DATE CREATED:   13 JUN 86                                  --
--  LAST MODIFIED:  03 DEC 86                                  --
--                                                             --
--  AUTHORS:        LCDR JEFFREY L. NIEDER                     --
--                  LT KARL S. FAIRBANKS, JR.                  --
--                                                             --
--  DESCRIPTION:  This procedure is the driver for AdaMeasure. --
--       It also contains the exception handler for the entire --
--       set of packages which comprise AdaMeasure.            --
--                                                             --
--*************************************************************--

with MENU_DISPLAY, GLOBAL_PARSER, GLOBAL, TEXT_IO;
use MENU_DISPLAY, GLOBAL_PARSER, GLOBAL, TEXT_IO;

procedure DEMON is
   package NEW_INTEGER_IO is new TEXT_IO.INTEGER_IO(integer);
   use NEW_INTEGER_IO;

begin
   DECLARATION := TRUE;
   INITIAL_MENU;

exception
   when PARSER_ERROR     =>  put(TOTAL_LINES_INPUT); new_line;
                                 put("Parser error");
   when SCANNER_ERROR    =>  put(NEXT_CHARACTER);
                                 put(character'pos(NEXT_CHARACTER)); new_line;
                                 put("   Error occured, program halted");
   when STATUS_ERROR     =>  put("Status error occured at line ");
                                 put(TOTAL_LINES_INPUT);
   when MODE_ERROR       =>  put("Mode error occured at line ");
                                 put(TOTAL_LINES_INPUT);
   when NAME_ERROR       =>  put("Name error occured at line ");
                                 put(TOTAL_LINES_INPUT);
   when USE_ERROR        =>  put("Use error occured at line ");
                                 put(TOTAL_LINES_INPUT);
   when DEVICE_ERROR     =>  put("Device error occured at line ");
                                 put(TOTAL_LINES_INPUT);
   when END_ERROR        =>  put("End error occured at line ");
                                 put(TOTAL_LINES_INPUT);
   when DATA_ERROR       =>  put("Data error occured at line ");
                                 put(TOTAL_LINES_INPUT);
   when LAYOUT_ERROR     =>  put("Layout error occured at line ");
                                 put(TOTAL_LINES_INPUT);
   when CONSTRAINT_ERROR =>  put("Constraint error occured at line ");
                                 put(TOTAL_LINES_INPUT);
   when NUMERIC_ERROR    =>  put("Numeric error occured at line ");
                                 put(TOTAL_LINES_INPUT);
   when STORAGE_ERROR    =>  put("Storage error occured at line ");
                                 put(TOTAL_LINES_INPUT);
   when PROGRAM_ERROR    =>  put("Program error occured at line ");
                                 put(TOTAL_LINES_INPUT);
   when QUIT_TO_OS       =>  CLEARSCREEN;
   when others           =>  put("Error occured");

end DEMON;
```

```
--************************************************************--
--                                                            --
--  TITLE:           AN ADA SOFTWARE METRIC                   --
--                                                            --
--  MODULE NAME:     DISPLAY_SUPPORT                          --
--  DATE CREATED:    11 OCT 86                                --
--  LAST MODIFIED:   04 DEC 86                                --
--                                                            --
--  AUTHORS:         LCDR JEFFREY L. NIEDER                   --
--                   LT KARL S. FAIRBANKS, JR.                --
--                                                            --
--  DESCRIPTION:  This package contains the procedures and    --
--       function for initializing the metric parameters, and --
--       supporting the user interface.                       --
--                                                            --
--************************************************************--

with HALSTEAD_METRIC, GLOBAL_PARSER, GLOBAL, TEXT_IO;
use HALSTEAD_METRIC, GLOBAL_PARSER, GLOBAL, TEXT_IO;

package DISPLAY_SUPPORT is
   procedure GET_FILENAME(TYPE_PRESENT : in out boolean);
   procedure GET_ANSWER(ERROR, FINISHED : in out boolean);
   function ADJUST_EDIT_BUFFER(INPUT_STRING : string;
                                         FILL_LENGTH : integer) return string;
   procedure RESET_PARAMETERS;
end DISPLAY_SUPPORT;

--------------------------------------------------------------------------------
--------------------------------------------------------------------------------

package body DISPLAY_SUPPORT is

   -- this is a user interface support procedure that prompts the user for
   --  the input file name, whenever the user must select a specific file.
procedure GET_FILENAME(TYPE_PRESENT : in out boolean) is
begin
   TYPE_PRESENT := FALSE;
   for I in 1..LINESIZE loop
      INPUT_FILE_NAME(I) := ' ';
      TEST_FILE_NAME(I)  := ' ';
      DATA_FILE_NAME(I)  := ' ';
   end loop;

   put("++++++++++++++++++++++++++++++++++++++++++++++++++");
   put("+++++++++++++++++++++++++++++"); new_line;
   put("+                                                ");
   put("                            +"); new_line;
   put("+           Input the name of the file you wish to");
   put(" analyze                    +"); new_line;
   put("+                                                ");
   put("                            +"); new_line;
   put("++++++++++++++++++++++++++++++++++++++++++++++++++");
   put("+++++++++++++++++++++++++++++"); new_line;
   new_line;
   put("Filename = ");

   get_line(INPUT_FILE_NAME, LENGTH_OF_LINE); new_line(2);
   for I in 1..LENGTH_OF_LINE loop
      if (INPUT_FILE_NAME(I) = '.') then
         TYPE_PRESENT := TRUE;
      end if;
   end loop;

   if (TYPE_PRESENT) then
      for I in 1..LENGTH_OF_LINE-4 loop
         DATA_FILE_NAME(I) := INPUT_FILE_NAME(I);
      end loop;
      TEST_FILE_NAME := INPUT_FILE_NAME;
```

```
      DATA_FILE_SIZE := LENGTH_OF_LINE - 4;

   else
      DATA_FILE_NAME := INPUT_FILE_NAME;
      for I in 1..LENGTH_OF_LINE loop
         TEST_FILE_NAME(I) := INPUT_FILE_NAME(I);
      end loop;
      DATA_FILE_SIZE := LENGTH_OF_LINE;
   end if;
end GET_FILENAME;

-------------------------------------------------------------------------------

   -- this user interface support procedure ensures that the user answers
   --  the question correctly, and determines if the user is finished.
procedure GET_ANSWER(ERROR, FINISHED : in out boolean) is
begin
   FINISHED := false;
   get(ANSWER);
   if (ANSWER = 'N') or (ANSWER = 'n') then
      FINISHED := TRUE;
      ERROR := FALSE;              -- user correctly said no
   elsif (ANSWER = 'Y') or (ANSWER = 'y') then
      ERROR := FALSE;              -- user correctly said yes
   else
      ERROR := TRUE;               -- user answered the question incorrectly
   end if;
end GET_ANSWER;

-------------------------------------------------------------------------------

   -- this formatting function places the input string in the edit buffer
   --  and fills the remaining buffer spaces with periods.
function ADJUST_EDIT_BUFFER(INPUT_STRING : string;
                                         FILL_LENGTH : integer) return string is
begin
   for I in 1..FILL_LENGTH loop
      EDIT_BUFFER(I) := INPUT_STRING(I);
   end loop;
   for I in (FILL_LENGTH+1)..EDIT_LINE_SIZE loop
      EDIT_BUFFER(I) := '.';
   end loop;
   return (EDIT_BUFFER);
end ADJUST_EDIT_BUFFER;

-------------------------------------------------------------------------------

   --  this procedure resets all of the metric parameters.
procedure RESET_PARAMETERS is
begin
   for I in TOKEN_AND..TOKEN_ASSIGNMENT loop
      OPERATOR_ARRAY(I) := 0;
   end loop;

   for I in IF_CONSTRUCT..CASE_CONSTRUCT loop
      CONSTRUCT_COUNT(I) := 0;
   end loop;

   for I in  FIRST_LEVEL_NEST..MAXIMUM_NESTING loop
      NESTED_COUNT(I) := 0;
   end loop;

   TOKEN_ARRAY_INDEX            := 0;
   PLACE_HOLDER_INDEX           := 0;
   TOTAL_LINES_INPUT            := 0;

   COMMENT_COUNT                := 0;

   CURRENT_NESTING_LEVEL        := 0;
```

```
    MAXIMUM_NESTING_LEVEL          := 0;
    NESTING_LINE_NUMBER            := 0;

    FIRST_TIME_LOAD                := TRUE;
    FULL                           := FALSE;
    NESTED_LEVEL_INCREASE          := TRUE;
end RESET_PARAMETERS;

end DISPLAY_SUPPORT;
```

```
--***********************************************************--
--                                                           --
--  TITLE:          AN ADA SOFTWARE METRIC                   --
--                                                           --
--  MODULE NAME:    GENERAL_DATA                             --
--  DATE CREATED:   14 OCT 86                                --
--  LAST MODIFIED:  03 DEC 86                                --
--                                                           --
--  AUTHORS:        LCDR JEFFREY L. NIEDER                   --
--                  LT KARL S. FAIRBANKS, JR.                --
--                                                           --
--  DESCRIPTION:  This package contains the procedure to display --
--       the comment count and nesting level metric data.    --
--                                                           --
--***********************************************************--

with DISPLAY_SUPPORT, HALSTEAD_METRIC, BYPASS_SUPPORT_FUNCTIONS, GLOBAL_PARSER,
      GLOBAL, TEXT_IO;
use DISPLAY_SUPPORT, HALSTEAD_METRIC, BYPASS_SUPPORT_FUNCTIONS, GLOBAL_PARSER,
     GLOBAL, TEXT_IO;

package GENERAL_DATA is
   package NEW_INTEGER_IO is new TEXT_IO.INTEGER_IO(integer);
   use NEW_INTEGER_IO;

   package REAL_IO is new TEXT_IO.FLOAT_IO(float);
   use REAL_IO;

   procedure VIEW_GENERAL;
end GENERAL_DATA;

-------------------------------------------------------------------------------
-------------------------------------------------------------------------------

package body GENERAL_DATA is

   -- this procedure computes the percentage of comments to total lines of the
   --  input file, and makes recommendations based on that percentage.  It also
   --  displays what nesting constructs were utilized, and the count of each
   --  nesting level attained up to the maximum nesting level reached.
procedure VIEW_GENERAL is
   RESULT : float;
   HOLD_CHARACTER : character;
   COUNT, NEST : integer;
begin
   GET_FILENAME(TYPE_PRESENT);
   CLEARSCREEN;
   open(DATA_FILE2, in_file, DATA_FILE_NAME & ".misc");

   CONVERT_UPPER_CASE(DATA_FILE_NAME, DATA_FILE_SIZE);
   put("      ");
   put("Comment count data for file ** ");
   put(ADJUST_LEXEME(DATA_FILE_NAME, DATA_FILE_SIZE));
   put(" **");
   new_line;
   put("------------------------------------------------------------------");
   new_line(2);
   put(ADJUST_EDIT_BUFFER("Total number of lines parsed", 28));
   get(DATA_FILE2, TOTAL_LINES_INPUT, 5);
   put(TOTAL_LINES_INPUT, 5);
   new_line;

   put(ADJUST_EDIT_BUFFER("Total number of comment lines parsed", 36));
   get(DATA_FILE2, COMMENT_COUNT, 5);
   put(COMMENT_COUNT, 5);
   new_line;
   get_line(DATA_FILE2, DUMMY_FILE_NAME, LENGTH_OF_LINE);

   RESULT := (float(COMMENT_COUNT) / float(TOTAL_LINES_INPUT)) * 100.0;
```

```
put(ADJUST_EDIT_BUFFER("Percentage of comments in the file", 34));
put(RESULT, 5, 1, 0);
new_line(2);
put("=================================================================");
new_line(2);
if (RESULT >= 0.0) and (RESULT < 20.0) then
   put("There is a low percentage of  comments to the total");
   new_line;
   put("number of lines in the file.  Unless utilization of");
   new_line;
   put("Ada's  extensive variable  identification has  been");
   new_line;
   put("applied, there may be too few comments for adequate");
   new_line;
   put("reader comprehension.");
   new_line;
elsif (RESULT >= 20.0) and (RESULT < 50.0) then
   put("There is a  reasonable  number of  comments to the");
   new_line;
   put("total number of lines in the file. This could help");
   new_line;
   put("a reader get a good  understanding of the program.");
   new_line;
elsif (RESULT >= 50.0) and (RESULT < 85.0) then
   put("There is a fairly high percentage of comments to the");
   new_line;
   put("total  number of lines in the file.  This could help");
   new_line;
   put("the reader get a good  understanding of the program,");
   new_line;
   put("but could run the risk of  obscuring the code in the");
   new_line;
   put("comments."); new_line;
else
   put("There is an  extremely high percentage of comments to");
   new_line;
   put("the total number of lines in the file. With this high");
   new_line;
   put("number of comments, there is possibility of obscuring");
   new_line;
   put("the code in the comments.");
   new_line;
end if;
new_line;
put("It must be clearly understood, that this assessment of comment lines");
new_line;
put("to lines of code is not a hard and  fast rule, but a suggestion that");
new_line;
put("may enhance the understanding of the code. ");
new_line(2);
put("=================================================================");
new_line(2);
put("          --- Enter any letter to continue ---");
new_line;
get(HOLD_CHARACTER);
CLEARSCREEN;
put("      ");
put("Nesting level data for file ** ");
put(ADJUST_LEXEME(DATA_FILE_NAME, DATA_FILE_SIZE));
put(" **");
new_line;
put("==============================================================");
new_line(2);
put("DECISION TYPE                                   UTILIZED"); new_line;
put("-----------------------------------------------------------"); new_line;
for I in IF_CONSTRUCT..CASE_CONSTRUCT loop
   get(DATA_FILE2, COUNT, 5);
   if (COUNT /= 0) then
      case I is
```

```
            when IF_CONSTRUCT =>
               put(ADJUST_EDIT_BUFFER("IF construct", 12));
               put(COUNT, 5); new_line;
            when LOOP_CONSTRUCT =>
               put(ADJUST_EDIT_BUFFER("LOOP construct", 14));
               put(COUNT, 5); new_line;
            when WHILE_CONSTRUCT =>
               put(ADJUST_EDIT_BUFFER("WHILE construct", 15));
               put(COUNT, 5); new_line;
            when FOR_CONSTRUCT =>
               put(ADJUST_EDIT_BUFFER("FOR construct", 13));
               put(COUNT, 5); new_line;
            when CASE_CONSTRUCT =>
               put(ADJUST_EDIT_BUFFER("CASE construct", 14));
               put(COUNT, 5); new_line;
            when others => null;
         end case;
      end if;
   end loop;
   new_line;

   get_line(DATA_FILE2, DUMMY_FILE_NAME, LENGTH_OF_LINE);
   get(DATA_FILE2, MAXIMUM_NESTING_LEVEL, 5);
   get_line(DATA_FILE2, DUMMY_FILE_NAME, LENGTH_OF_LINE);
   get(DATA_FILE2, NESTING_LINE_NUMBER, 5);
   get_line(DATA_FILE2, DUMMY_FILE_NAME, LENGTH_OF_LINE);

   put(ADJUST_EDIT_BUFFER("Maximum nesting level", 21));
   put(MAXIMUM_NESTING_LEVEL, 5);
   new_line;

   put(ADJUST_EDIT_BUFFER("Initial occurence line number", 29));
   put(NESTING_LINE_NUMBER, 5);
   new_line(2);

   for I in FIRST_LEVEL_NEST..MAXIMUM_NESTING_LEVEL loop
      get(DATA_FILE2, NEST, 5);
      put("Total nesting "); put(I, 2); put(" deep occured");
      put(NEST, 3); put(" times."); new_line;
   end loop;
   new_line(2);
   put("          --- Enter any letter to continue ---");
   new_line;
   get(HOLD_CHARACTER);
   get_line(DATA_FILE2, DUMMY_FILE_NAME, LENGTH_OF_LINE);

   close(DATA_FILE2);
end VIEW_GENERAL;

end GENERAL_DATA;
```

```
--*********************************************************************--
--                                                                     --
--  TITLE:          AN ADA SOFTWARE METRIC                             --
--                                                                     --
--  MODULE NAME:    PACKAGE GET_NEXT_CHARACTER                         --
--  DATE CREATED:   13 JUN 86                                          --
--  LAST MODIFIED:  04 NOV 86                                          --
--                                                                     --
--  AUTHORS:        LCDR JEFFREY L. NIEDER                             --
--                  LT KARL S. FAIRBANKS, JR.                          --
--                                                                     --
--  DESCRIPTION:  This package contains the procedures which           --
--       fills the buffer from the input file and returns the          --
--       the next character from the buffer when called.               --
--                                                                     --
--*********************************************************************--

with GLOBAL, TEXT_IO;
use GLOBAL, TEXT_IO;

package GET_NEXT_CHARACTER is
   procedure GETNEXTCHARACTER(NEXT_CHARACTER, LOOKAHEAD_ONE_CHARACTER :
                                           out character);
   procedure FILL_BUFFER(INPUT_LINE : out INPUT_CODE_LINE);
end GET_NEXT_CHARACTER;

--------------------------------------------------------------------------------
--------------------------------------------------------------------------------

package body GET_NEXT_CHARACTER is

   -- this procedure gets the next character to be manipulated in
   --  the creation of each token
procedure GETNEXTCHARACTER(NEXT_CHARACTER, LOOKAHEAD_ONE_CHARACTER :
                                        out character) is

   -- if the last character is read from the input buffer then it is
   --  time to refill the buffer, and reset the index variables
begin
   if NEXT_BUFFER_INDEX = REFILL_BUFFER_INDEX then
      FILL_BUFFER(INPUT_LINE);
      CURRENT_BUFFER_INDEX := 0;
      NEXT_BUFFER_INDEX := 1;
   end if;
   if NEXT_BUFFER_INDEX = INPUT_LINE_SIZE then
      LOOKAHEAD_ONE_CHARACTER := ASCII.CR;
   else
      LOOKAHEAD_ONE_CHARACTER := INPUT_LINE(NEXT_BUFFER_INDEX + 1);
   end if;
   NEXT_CHARACTER := INPUT_LINE(NEXT_BUFFER_INDEX);
   CURRENT_BUFFER_INDEX := NEXT_BUFFER_INDEX;
   NEXT_BUFFER_INDEX := NEXT_BUFFER_INDEX + 1;
end GETNEXTCHARACTER;

--------------------------------------------------------------------------------

procedure FILL_BUFFER(INPUT_LINE : out INPUT_CODE_LINE) is
begin
   for i in 1..INPUT_LINE_SIZE loop  -- reset the input buffer to all $'s
      INPUT_LINE(i) := '$';
   end loop;
   get_line(TEST_FILE, INPUT_LINE, INPUT_LINE_SIZE);
   TOTAL_LINES_INPUT := TOTAL_LINES_INPUT + 1;
   REFILL_BUFFER_INDEX := INPUT_LINE_SIZE + 1;
end FILL_BUFFER;

end GET_NEXT_CHARACTER;
```

```
--**********************************************************--
--                                                          --
--  TITLE:          AN ADA SOFTWARE METRIC                  --
--                                                          --
--  MODULE NAME:    PACKAGE GLOBAL                          --
--  DATE CREATED:   13 JUN 86                               --
--  LAST MODIFIED:  16 OCT 86                               --
--                                                          --
--  AUTHORS:        LCDR JEFFREY L. NIEDER                  --
--                  LT KARL S. FAIRBANKS, JR.               --
--                                                          --
--  DESCRIPTION:  This package contains all the global type,   --
--       subtype, and variable declarations.                --
--                                                          --
--**********************************************************--

with TEXT_IO;
package NEW_INTEGER_IO is new TEXT_IO.INTEGER_IO(integer);

--------------------------------------------------------------------------------
--------------------------------------------------------------------------------

with TEXT_IO, NEW_INTEGER_IO;
use TEXT_IO, NEW_INTEGER_IO;

package GLOBAL is

LINESIZE : constant integer := 100;

-- Ada token classes --
type TOKEN is (IDENTIFIER, SEPARATOR, NUMERIC_LIT, DELIMITER, COMMENT,
                       CHARACTER_LIT, STRING_LIT, ILLEGAL);

-- record to hold the token built up by the scanner, the value is the
--  token's position (POS) in the token list, the lexeme is the actual
--  string for that particular token
type TOKEN_RECORD_TYPE is
   record
      TOKEN_TYPE   : TOKEN;
      TOKEN_VALUE  : integer;
      LEXEME       : string(1..LINESIZE);
      LEXEME_SIZE  : natural;
   end record;

-- this array is the input buffer, it holds each line of code when
--    read from the input file
subtype INPUT_CODE_LINE is string(1..LINESIZE);

subtype UPPER_CASE_LETTER is character range 'A'..'Z';
subtype LOWER_CASE_LETTER is character range 'a'..'z';
subtype UPPER_CASE_HEX is UPPER_CASE_LETTER range 'A'..'F';
subtype LOWER_CASE_HEX is LOWER_CASE_LETTER range 'a'..'f';

subtype DIGITS_TYPE is character range '0'..'9';

-- the following subtype declarations make use of the POS attribute
--   which returns the integer value of the particular ASCII
--   character argument

-- set of formators characterized by their ASCII value --
-- formators are horizontal tab, line feed, vertical tab, form feed,
--   and carraige return
subtype FORMATORS is integer
   range character'pos(ASCII.HT)..character'pos(ASCII.CR);

-- first set of delimiters characterized by their ASCII value --
-- delimiters are ampersand, accent mark, left paren, right paren,
--   asterisk, plus sign, comma, dash, period, slash
subtype DELIMITER1 is integer
```

```
   range character'pos('&')..character'pos('/');

-- second set of delimiters characterized by their ASCII value --
-- delimiters are colon, semi-colon, less than, equal, greater than
subtype DELIMITER2 is integer
   range character'pos(':')..character'pos('>');

-- compound delimiters whose first symbol is in second set of delimiters --
-- the entire set of compound delimiters are <=, >=, /=, **, <<, >>, =>,
--    :=, <>, ..
subtype COMPOUND_DELIMITER is DELIMITER2
   range character'pos('<')..character'pos('>');

TEST_FILE, RESULT_FILE          : file_type;
INPUT_FILE_NAME                 : string(1..LINESIZE);
NEXT_CHARACTER                  : character;
LOOKAHEAD_ONE_CHARACTER         : character;
CURRENT_BUFFER_INDEX            : integer;
NEXT_BUFFER_INDEX               : integer := 0;
TOKEN_RECORD                    : TOKEN_RECORD_TYPE;
INPUT_LINE                      : INPUT_CODE_LINE;
TOTAL_LINES_INPUT               : integer := 0;
REFILL_BUFFER_INDEX             : natural := 0;
LEXEME_LENGTH, INPUT_LINE_SIZE  : natural;
TOKEN_CLASS                     : TOKEN;

procedure ERROR_MESSAGE(TOKEN_CLASS : in out TOKEN);
SCANNER_ERROR                   : exception;

end GLOBAL;

-----------------------------------------------------------------------------
-----------------------------------------------------------------------------

package body GLOBAL is

-- procedure called when an error is detected by any of the token class
--   routines, an integer value is passed identifying which routine called
--   this procedure, and the SCANNER_ERROR exception is raised.
procedure ERROR_MESSAGE(TOKEN_CLASS : in out TOKEN) is
   SCANNER_ERROR_VALUE : integer;
begin
   SCANNER_ERROR_VALUE := TOKEN'pos(TOKEN_CLASS);
   case SCANNER_ERROR_VALUE is
      when 0 =>  put(RESULT_FILE, "Illegal identifier at line number ");
      when 1 =>  put(RESULT_FILE, "Illegal separator at line number ");
      when 2 =>  put(RESULT_FILE, "Illegal numeric literal at line number ");
      when 3 =>  put(RESULT_FILE, "Illegal delimiter at line number ");
      when 4 =>  put(RESULT_FILE, "Illegal comment at line number ");
      when 5 =>  put(RESULT_FILE, "Illegal character literal at line number ");
      when 6 =>  put(RESULT_FILE, "Illegal string literal at line number ");
      when 7 =>  put(RESULT_FILE, "Illegal first character at line number ");
      when others =>  null;
   end case;
   put(RESULT_FILE, TOTAL_LINES_INPUT);
   new_line(RESULT_FILE);

   raise SCANNER_ERROR;
end ERROR_MESSAGE;

end GLOBAL;
```

```
--*****************************************************************--
--                                                                 --
--  TITLE:          AN ADA SOFTWARE METRIC                         --
--                                                                 --
--  MODULE NAME:    PACKAGE GLOBAL_PARSER                          --
--  DATE CREATED:   17 JUL 86                                      --
--  LAST MODIFIED:  03 DEC 86                                      --
--                                                                 --
--  AUTHORS:        LCDR JEFFREY L. NIEDER                         --
--                  LT KARL S. FAIRBANKS, JR.                      --
--                                                                 --
--  DESCRIPTION:  This package contains the global variables       --
--       used by the parser and metric.  It also contains all      --
--       of the declarations of the reserved words and reserved    --
--       symbols recognized by the language.                       --
--                                                                 --
--*****************************************************************--

with GLOBAL, TEXT_IO;
use GLOBAL, TEXT_IO;

package GLOBAL_PARSER is

TOKEN_ARRAY_SIZE                        : constant integer := 50;
EDIT_LINE_SIZE                          : constant integer := 50;

TOKEN_IDENTIFIER                        : constant integer := 1;
TOKEN_NUMERIC_LITERAL                   : constant integer := 2;
TOKEN_CHARACTER_LITERAL                 : constant integer := 3;
TOKEN_STRING_LITERAL                    : constant integer := 4;
TOKEN_END                               : constant integer := 5;
TOKEN_BEGIN                             : constant integer := 6;
TOKEN_IF                                : constant integer := 7;
TOKEN_THEN                              : constant integer := 8;
TOKEN_ELSIF                             : constant integer := 9;
TOKEN_ELSE                              : constant integer := 10;
TOKEN_WHILE                             : constant integer := 11;
TOKEN_LOOP                              : constant integer := 12;
TOKEN_CASE                              : constant integer := 13;
TOKEN_WHEN                              : constant integer := 14;
TOKEN_DECLARE                           : constant integer := 15;
TOKEN_FOR                               : constant integer := 16;
TOKEN_OTHERS                            : constant integer := 17;
TOKEN_RETURN                            : constant integer := 18;
TOKEN_EXIT                              : constant integer := 19;
TOKEN_PROCEDURE                         : constant integer := 20;
TOKEN_FUNCTION                          : constant integer := 21;
TOKEN_WITH                              : constant integer := 22;
TOKEN_USE                               : constant integer := 23;
TOKEN_PACKAGE                           : constant integer := 24;
TOKEN_BODY                              : constant integer := 25;
TOKEN_RANGE                             : constant integer := 26;
TOKEN_IN                                : constant integer := 27;
TOKEN_OUT                               : constant integer := 28;
TOKEN_SUBTYPE                           : constant integer := 29;
TOKEN_TYPE                              : constant integer := 30;
TOKEN_IS                                : constant integer := 31;
TOKEN_NULL                              : constant integer := 32;
TOKEN_ACCESS                            : constant integer := 33;
TOKEN_ARRAY                             : constant integer := 34;
TOKEN_DIGITS                            : constant integer := 35;
TOKEN_DELTA                             : constant integer := 36;
TOKEN_RECORD_STRUCTURE                  : constant integer := 37;
TOKEN_CONSTANT                          : constant integer := 38;
TOKEN_NEW                               : constant integer := 39;
TOKEN_EXCEPTION                         : constant integer := 40;
TOKEN_RENAMES                           : constant integer := 41;
TOKEN_PRIVATE                           : constant integer := 42;
TOKEN_LIMITED                           : constant integer := 43;
```

```
TOKEN_TASK                          : constant integer := 44;
TOKEN_ENTRY                         : constant integer := 45;
TOKEN_ACCEPT                        : constant integer := 46;
TOKEN_DELAY                         : constant integer := 47;
TOKEN_SELECT                        : constant integer := 48;
TOKEN_TERMINATE                     : constant integer := 49;
TOKEN_ABORT                         : constant integer := 50;
TOKEN_SEPARATE                      : constant integer := 51;
TOKEN_RAISE                         : constant integer := 52;
TOKEN_GENERIC                       : constant integer := 53;
TOKEN_AT                            : constant integer := 54;
TOKEN_REVERSE                       : constant integer := 55;
TOKEN_DO                            : constant integer := 56;
TOKEN_GOTO                          : constant integer := 57;
TOKEN_OF                            : constant integer := 58;
TOKEN_ALL                           : constant integer := 59;
TOKEN_PRAGMA                        : constant integer := 60;

TOKEN_AND                           : constant integer := 61;
TOKEN_OR                            : constant integer := 62;
TOKEN_NOT                           : constant integer := 63;
TOKEN_XOR                           : constant integer := 64;
TOKEN_MOD                           : constant integer := 65;
TOKEN_REM                           : constant integer := 66;
TOKEN_ABSOLUTE                      : constant integer := 67;
TOKEN_ASTERISK                      : constant integer := 68;
TOKEN_SLASH                         : constant integer := 69;
TOKEN_EXPONENT                      : constant integer := 70;
TOKEN_PLUS                          : constant integer := 71;
TOKEN_MINUS                         : constant integer := 72;
TOKEN_AMPERSAND                     : constant integer := 73;
TOKEN_EQUALS                        : constant integer := 74;
TOKEN_NOT_EQUALS                    : constant integer := 75;
TOKEN_LESS_THAN                     : constant integer := 76;
TOKEN_LESS_THAN_EQUALS              : constant integer := 77;
TOKEN_GREATER_THAN                  : constant integer := 78;
TOKEN_GREATER_THAN_EQUALS           : constant integer := 79;
TOKEN_ASSIGNMENT                    : constant integer := 80;

TOKEN_SEMICOLON                     : constant integer := 81;
TOKEN_PERIOD                        : constant integer := 82;
TOKEN_LEFT_PAREN                    : constant integer := 83;
TOKEN_RIGHT_PAREN                   : constant integer := 84;
TOKEN_COLON                         : constant integer := 85;
TOKEN_COMMA                         : constant integer := 86;
TOKEN_APOSTROPHE                    : constant integer := 87;
TOKEN_RANGE_DOTS                    : constant integer := 88;
TOKEN_ARROW                         : constant integer := 89;
TOKEN_BAR                           : constant integer := 90;
TOKEN_BRACKETS                      : constant integer := 91;
TOKEN_LEFT_BRACKET                  : constant integer := 92;
TOKEN_RIGHT_BRACKET                 : constant integer := 93;

type TOKEN_RECORD_BUFFER_ARRAY is
    array (0..TOKEN_ARRAY_SIZE) of TOKEN_RECORD_TYPE;

TOKEN_RECORD_BUFFER                 : TOKEN_RECORD_BUFFER_ARRAY;
CURRENT_TOKEN_RECORD                : TOKEN_RECORD_TYPE;
LOOK_AHEAD_TOKEN                    : TOKEN_RECORD_TYPE;

TOKEN_ARRAY_INDEX                   : integer := 0;
LENGTH_OF_LINE                      : integer := 0;
PLACE_HOLDER_INDEX                  : integer := 0;
COMMENT_COUNT                       : integer := 0;
DATA_FILE_SIZE                      : integer := 0;
STATUS_COUNTER                      : integer := 0;

FULL                                : boolean := FALSE;
FINISHED                            : boolean := FALSE;
```

```
RESERVE_WORD_TEST                     : boolean := FALSE;
FIRST_TIME_LOAD                       : boolean := TRUE;
PROCEDURE_TEST                        : boolean := FALSE;
ERROR                                 : boolean := FALSE;
TYPE_PRESENT                          : boolean := FALSE;
DECLARATION                           : boolean;

TEST_FILE_NAME                        : string(1..LINESIZE);
DATA_FILE_NAME                        : string(1..LINESIZE);
DUMMY_FILE_NAME                       : string(1..LINESIZE);
EDIT_BUFFER                           : string(1..EDIT_LINE_SIZE);

ANSWER                                : character;
DATA_FILE1, DATA_FILE2                : file_type;
DATA_FILE3, DATA_FILE4                : file_type;
PARSER_ERROR                          : exception;
QUIT_TO_OS                            : exception;

procedure CLEARSCREEN;
procedure SYNTAX_ERROR(ERROR_MESSAGE : string);

end GLOBAL_PARSER;

--------------------------------------------------------------------------------
--------------------------------------------------------------------------------

package body GLOBAL_PARSER is

procedure CLEARSCREEN is
begin
   put(ASCII.ESC & "2J");
end CLEARSCREEN;

--------------------------------------------------------------------------------

procedure SYNTAX_ERROR(ERROR_MESSAGE : string) is
begin
   put("Incomplete ");
   put(ERROR_MESSAGE);
   put(" at line number");

   put(RESULT_FILE, "Incomplete ");
   put(RESULT_FILE, ERROR_MESSAGE);
   put(RESULT_FILE, " at line number");

   raise PARSER_ERROR;
end SYNTAX_ERROR;

end GLOBAL_PARSER;
```

```
--***********************************************************--
--                                                           --
--  TITLE:          AN ADA SOFTWARE METRIC                   --
--                                                           --
--  MODULE NAME:    HALSTEAD_DISPLAY                         --
--  DATE CREATED:   11 OCT 86                                --
--  LAST MODIFIED:  03 DEC 86                                --
--                                                           --
--  AUTHORS:        LCDR JEFFREY L. NIEDER                   --
--                  LT KARL S. FAIRBANKS, JR.                --
--                                                           --
--  DESCRIPTION:  This package contains all of the procedures  --
--       and functions necessary to implement Halstead's length  --
--       metric.                                             --
--                                                           --
--***********************************************************--

with DISPLAY_SUPPORT, HALSTEAD_METRIC, BYPASS_SUPPORT_FUNCTIONS, GLOBAL_PARSER,
      GLOBAL, TEXT_IO;
use DISPLAY_SUPPORT, HALSTEAD_METRIC, BYPASS_SUPPORT_FUNCTIONS, GLOBAL_PARSER,
      GLOBAL, TEXT_IO;

package HALSTEAD_DISPLAY is
   package NEW_INTEGER_IO is new TEXT_IO.INTEGER_IO(integer);
   use NEW_INTEGER_IO;

   package REAL_IO is new TEXT_IO.FLOAT_IO(float);
   use REAL_IO;

   procedure HALSTEAD;
   procedure VIEW_OPERATORS;
   procedure OPERAND_MENU;
   procedure VIEW_SCOPE_STRUCTURES;
   procedure VIEW_VARIABLES;
   procedure VIEW_BLOCKS;
   procedure METRIC_CONCLUSIONS;
   function LOG2(NUMBER : float) return float;
   function NATURAL_LOG(NUMBER : float) return float;
end HALSTEAD_DISPLAY;

--------------------------------------------------------------------------------
--------------------------------------------------------------------------------

package body HALSTEAD_DISPLAY is

   -- this procedure provides a menu of selections for viewing Halstead's
   --  length metric data.  It also loads the symbol table array.
procedure HALSTEAD is
   DONE : boolean := FALSE;
   DUMMY_LINE_LENGTH : integer;
   LEXEME_NAME :string(1..LINESIZE);
begin
   GET_FILENAME(TYPE_PRESENT);
   while not (DONE) loop
      CLEARSCREEN;
      new_line;
      put("*******************************************************");
      put("**********************"); new_line;
      put("*                                                     ");
      put("                    *"); new_line;
      put("*                          HALSTEAD SELECTION MENU      ");
      put("                    *"); new_line;
      put("*                                                     ");
      put("                    *"); new_line;
      put("*                                                     ");
      put("                    *"); new_line;
      put("*            HERE ARE THE HALSTEAD METRIC OPTIONS AVAILAB");
      put("LE TO YOU           *"); new_line;
      put("*                                                     ");
```

```
      put("                        *"); new_line;
      put("*                 Simply enter the number of your choice");
      put("                        *"); new_line;
      put("*                                                       ");
      put("                        *"); new_line;
      put("*             1 - HALSTEAD OPERATORS                     ");
      put("                        *"); new_line;
      put("*                                                       ");
      put("                        *"); new_line;
      put("*             2 - HALSTEAD OPERANDS                      ");
      put("                        *"); new_line;
      put("*                                                       ");
      put("                        *"); new_line;
      put("*             3 - HALSTEAD METRIC CONCLUSIONS            ");
      put("                        *"); new_line;
      put("*                                                       ");
      put("                        *"); new_line;
      put("*             4 - EXIT TO METRIC SELECTION MENU          ");
      put("                        *"); new_line;
      put("*                                                       ");
      put("                        *"); new_line;
      put("*             5 - EXIT TO OPERATING SYSTEM               ");
      put("                        *"); new_line;
      put("*                                                       ");
      put("                        *"); new_line;
      put("*********************************************************");
      put("************************"); new_line(2);
      put("Choice = ");
      get(ANSWER);
      get_line(DUMMY_FILE_NAME, DUMMY_LINE_LENGTH);      -- flush system input
                                                                  --    buffer
         -- load the symbol table array --
      open(DATA_FILE3, in_file, DATA_FILE_NAME & ".rand");
      get(DATA_FILE3, LAST_ENTRY_INDEX, 5);
      get(DATA_FILE3, TOTAL_OPERAND_COUNT, 5);
      get_line(DATA_FILE3, DUMMY_FILE_NAME, LENGTH_OF_LINE);
      for I in 0..LAST_ENTRY_INDEX-1 loop
         get(DATA_FILE3, SYMBOL_TABLE(I).SCOPE, 5);
         get(DATA_FILE3, SYMBOL_TABLE(I).REFERENCE, 5);
         get(DATA_FILE3, SYMBOL_TABLE(I).DECLARATION_TYPE, 5);
         get_line(DATA_FILE3, LEXEME_NAME, LENGTH_OF_LINE);
         NEW_NODE := new OPERAND_TYPE;
         NEW_NODE.OPERAND := LEXEME_NAME;
         NEW_NODE.SIZE := LENGTH_OF_LINE;
         NEW_NODE.NEXT_OPERAND := null;
         SYMBOL_TABLE(I).LEXEME_ADDRESS := NEW_NODE;
      end loop;
      close(DATA_FILE3);

      new_line(2);
      case ANSWER is
         when '1' => VIEW_OPERATORS;
         when '2' => OPERAND_MENU;
         when '3' => METRIC_CONCLUSIONS;
         when '4' => DONE := TRUE;
         when '5' => raise QUIT_TO_OS;
         when others => null;
      end case;
   end loop;
end HALSTEAD;

--------------------------------------------------------------------------------

   -- this procedure displays the Halstead operator metric data.
procedure VIEW_OPERATORS is
   DONE                          : boolean;
   OCCURENCES, OPERATORS_USED    : integer := 0;
   HOLD_CHARACTER                : character;
   LEXEME_NAME                   : string(1..LINESIZE);
```

```
begin
   CLEARSCREEN;
   open(DATA_FILE1, in_file, DATA_FILE_NAME & ".data");
   put("*****************************************************");
   put("**********************"); new_line(2);

   CONVERT_UPPER_CASE(DATA_FILE_NAME, DATA_FILE_SIZE);
   put("          Operator data for file ** ");
   put(ADJUST_LEXEME(DATA_FILE_NAME, DATA_FILE_SIZE));
   put(" **"); new_line(2);
   put("OPERATOR                                          UTILIZED"); new_line;
   put("-----------------------------------------------------------"); new_line;

   for I in TOKEN_AND..TOKEN_ASSIGNMENT loop
      get(DATA_FILE1, OCCURENCES);
      if (OCCURENCES /= 0) then
         case I is
            when TOKEN_AND =>
               put(ADJUST_EDIT_BUFFER("Boolean 'AND'", 13));
            when TOKEN_OR =>
               put(ADJUST_EDIT_BUFFER("Boolean 'OR'", 12));
            when TOKEN_NOT =>
               put(ADJUST_EDIT_BUFFER("Boolean 'NOT'", 13));
            when TOKEN_XOR =>
               put(ADJUST_EDIT_BUFFER("Boolean 'XOR'", 13));
            when TOKEN_MOD =>
               put(ADJUST_EDIT_BUFFER("Modulus 'MOD'", 13));
            when TOKEN_REM =>
               put(ADJUST_EDIT_BUFFER("Remainder 'REM'", 15));
            when TOKEN_ABSOLUTE =>
               put(ADJUST_EDIT_BUFFER("Absolute Value 'ABS'", 20));
            when TOKEN_ASTERISK =>
               put(ADJUST_EDIT_BUFFER("Multiplication '*'", 18));
            when TOKEN_SLASH =>
               put(ADJUST_EDIT_BUFFER("Division '/'", 12));
            when TOKEN_EXPONENT =>
               put(ADJUST_EDIT_BUFFER("Exponentiation '**'", 19));
            when TOKEN_PLUS =>
               put(ADJUST_EDIT_BUFFER("Addition '+'", 12));
            when TOKEN_MINUS =>
               put(ADJUST_EDIT_BUFFER("Subtraction '-'", 15));
            when TOKEN_AMPERSAND =>
               put(ADJUST_EDIT_BUFFER("Catenation '&'", 14));
            when TOKEN_EQUALS =>
               put(ADJUST_EDIT_BUFFER("Equality '='", 12));
            when TOKEN_NOT_EQUALS =>
               put(ADJUST_EDIT_BUFFER("Inequality '/='", 15));
            when TOKEN_LESS_THAN =>
               put(ADJUST_EDIT_BUFFER("Less Than '<'", 13));
            when TOKEN_LESS_THAN_EQUALS =>
               put(ADJUST_EDIT_BUFFER("Less Than Equals '<='", 21));
            when TOKEN_GREATER_THAN =>
               put(ADJUST_EDIT_BUFFER("Greater Than '>'", 16));
            when TOKEN_GREATER_THAN_EQUALS =>
               put(ADJUST_EDIT_BUFFER("Greater Than Equals '>='", 24));
            when TOKEN_ASSIGNMENT =>
               put(ADJUST_EDIT_BUFFER("Assignment ':='", 15));
            when others                    => null;
         end case;
         put(OCCURENCES,5);
         new_line;
      end if;                        -- if occurences /= 0
   end loop;
   get_line(DATA_FILE1, DUMMY_FILE_NAME, LENGTH_OF_LINE);

   for I in IF_CONSTRUCT..CASE_CONSTRUCT loop
      get(DATA_FILE1, OCCURENCES, 5);
      if (OCCURENCES /= 0) then
         case I is
```

```
            when IF_CONSTRUCT =>
               put(ADJUST_EDIT_BUFFER("IF construct", 12));
            when LOOP_CONSTRUCT =>
               put(ADJUST_EDIT_BUFFER("LOOP construct", 14));
            when WHILE_CONSTRUCT =>
               put(ADJUST_EDIT_BUFFER("WHILE construct", 15));
            when FOR_CONSTRUCT =>
               put(ADJUST_EDIT_BUFFER("FOR construct", 13));
            when CASE_CONSTRUCT =>
               put(ADJUST_EDIT_BUFFER("CASE construct", 14));
            when others => null;
         end case;
         put(OCCURENCES, 5); new_line;
      end if;
   end loop;

   new_line;
   put(ADJUST_EDIT_BUFFER("Number of individual operators used", 35));
   get(DATA_FILE1, OPERATORS_USED);
   put(OPERATORS_USED, 5);
   new_line;
   put(ADJUST_EDIT_BUFFER("Total number of occurences", 26));
   get(DATA_FILE1, OCCURENCES);
   put(OCCURENCES, 5);
   new_line(2);
   close(DATA_FILE1);

   put("                  --- Enter any letter to continue ---");
   new_line;
   get(HOLD_CHARACTER);
end VIEW_OPERATORS;

--------------------------------------------------------------------------------

   -- this procedure provides a menu of selections for viewing the
   --  Halstead operand metric data.
procedure OPERAND_MENU is
   DONE : boolean := FALSE;
   DUMMY_LINE_LENGTH : integer;
begin
   while not (DONE) loop
      CLEARSCREEN;
      new_line;
      put("*********************************************************");
      put("**********************"); new_line;
      put("*                                                       ");
      put("                           *"); new_line;
      put("*                            HALSTEAD OPERAND SELECTION MENU ");
      put("                           *"); new_line;
      put("*                                                       ");
      put("                           *"); new_line;
      put("*                                                       ");
      put("                           *"); new_line;
      put("*                          HERE IS THE OPERAND DATA AVAILABLE");
      put("                           *"); new_line;
      put("*                                                       ");
      put("                           *"); new_line;
      put("*                      Simply enter the number of your choice");
      put("                           *"); new_line;
      put("*                                                       ");
      put("                           *"); new_line;
      put("*                  1 - PROCEDURE, FUNCTION, PACKAGE INFORMATI");
      put("ON                         *"); new_line;
      put("*                                                       ");
      put("                           *"); new_line;
      put("*                  2 - VARIABLES AND CONSTANTS INFORMATION   ");
      put("                           *"); new_line;
      put("*                                                       ");
      put("                           *"); new_line;
```

```
      put("*              3 - TASKS AND BLOCKS INFORMATION          ");
      put("                       *"); new_line;
      put("*                                                        ");
      put("                       *"); new_line;
      put("*              4 - EXIT TO HALSTEAD SELECTION MENU       ");
      put("                       *"); new_line;
      put("*                                                        ");
      put("                       *"); new_line;
      put("*              5 - EXIT TO OPERATING SYSTEM              ");
      put("                       *"); new_line;
      put("*                                                        ");
      put("                       *"); new_line;
      put("*****************************************************");
      put("**********************"); new_line(2);
      put("Choice = ");
      get(ANSWER);
      get_line(DUMMY_FILE_NAME, DUMMY_LINE_LENGTH);        -- flush system input
                                                                              --    buffer
      new_line(2);
      case ANSWER is
         when '1' => VIEW_SCOPE_STRUCTURES;
         when '2' => VIEW_VARIABLES;
         when '3' => VIEW_BLOCKS;
         when '4' => DONE := TRUE;
         when '5' => raise QUIT_TO_OS;
         when others => null;
      end case;
   end loop;
end OPERAND_MENU;

--------------------------------------------------------------------------------

   -- this procedure displays the Halstead operand metric data for
   --   packages, procedures, and functions.
procedure VIEW_SCOPE_STRUCTURES is
   SCREEN_COUNTER : integer := 0;
   NAME           : string(1..LINESIZE);
   SIZE, COUNT    : integer;
   HOLD_CHARACTER : character;
begin
   CLEARSCREEN;
   put("*****************************************************");
   put("**********************"); new_line(2);

   CONVERT_UPPER_CASE(DATA_FILE_NAME, DATA_FILE_SIZE);
   for DECLARE_TYPE in PACKAGE_DECLARE..FUNCTION_DECLARE loop
      case DECLARE_TYPE is
         when PACKAGE_DECLARE   =>
            put("  PACKAGES for file - ");
         when PROCEDURE_DECLARE =>
            put("  PROCEDURES for file - ");
         when FUNCTION_DECLARE  =>
            put("  FUNCTIONS for file - ");
         when others            =>  null;
      end case;
      put(ADJUST_LEXEME(DATA_FILE_NAME, DATA_FILE_SIZE)); new_line(2);
      put("NAME                                          REFERENCED"); new_line;
      put("----------------------------------------------------------"); new_line;

      for I in 0..(LAST_ENTRY_INDEX-1) loop
         NAME  := SYMBOL_TABLE(I).LEXEME_ADDRESS.OPERAND;
         SIZE  := SYMBOL_TABLE(I).LEXEME_ADDRESS.SIZE;
         COUNT := SYMBOL_TABLE(I).REFERENCE;
         if (SYMBOL_TABLE(I).DECLARATION_TYPE = DECLARE_TYPE) then
            put(ADJUST_EDIT_BUFFER(NAME, SIZE));
            put(COUNT, 5); new_line;
            SCREEN_COUNTER := SCREEN_COUNTER + 1;
            if (SCREEN_COUNTER = 10) then
               new_line(3);
```

```
            put("                --- Enter any letter to continue ---");
            new_line;
            get(HOLD_CHARACTER);
            CLEARSCREEN;
            SCREEN_COUNTER := 0;
            case DECLARE_TYPE is
               when PACKAGE_DECLARE   =>
                  put("  PACKAGES for file - ");
               when PROCEDURE_DECLARE =>
                  put("  PROCEDURES for file - ");
               when FUNCTION_DECLARE  =>
                  put("  FUNCTIONS for file - ");
               when others            =>  null;
            end case;
            put(ADJUST_LEXEME(DATA_FILE_NAME, DATA_FILE_SIZE)); new_line(2);
            put("NAME                                              REFERENCED");
            new_line;
            put("----------------------------------------------------");
            new_line;
         end if;                          -- if screen_counter = 10
      end if;                            -- if symbol_table(i).declaration_type
   end loop;                            -- for i in 0..(last_entry_index-1)
   new_line(2);
   put("                --- Enter any letter to continue ---");
   new_line;
   get(HOLD_CHARACTER);
   CLEARSCREEN;
   SCREEN_COUNTER := 0;
 end loop;                              -- for declare_type in
end VIEW_SCOPE_STRUCTURES;

--------------------------------------------------------------------------------

   -- this procedure displays the Halstead operand metric data for
   --  variables, numeric constants, and global variables.
procedure VIEW_VARIABLES is
   SCREEN_COUNTER : integer := 0;
   NAME           : string(1..LINESIZE);
   SIZE, COUNT    : integer;
   HOLD_CHARACTER : character;
   SKIP           : boolean;
   CONTINUE       : boolean;
begin
   CLEARSCREEN;
   put("*******************************************************");
   put("***********************"); new_line(2);

   CONVERT_UPPER_CASE(DATA_FILE_NAME, DATA_FILE_SIZE);
   for DECLARE_TYPE in VARIABLE_DECLARE..NO_DECLARE loop
      SKIP := FALSE;
      CONTINUE := FALSE;
      case DECLARE_TYPE is
         when VARIABLE_DECLARE =>
            put("  VARIABLES for file - ");
         when CONSTANT_DECLARE =>
            put("  CONSTANTS for file - ");
         when NO_DECLARE       =>
            put("  GLOBAL VARIABLES for file - ");
         when others           =>  null;
      end case;
      put(ADJUST_LEXEME(DATA_FILE_NAME, DATA_FILE_SIZE)); new_line(2);
      put("NAME                                              REFERENCED"); new_line;
      put("----------------------------------------------------"); new_line;

      while not (SKIP) loop
         for I in 0..(LAST_ENTRY_INDEX-1) loop
            NAME  := SYMBOL_TABLE(I).LEXEME_ADDRESS.OPERAND;
            SIZE  := SYMBOL_TABLE(I).LEXEME_ADDRESS.SIZE;
            COUNT := SYMBOL_TABLE(I).REFERENCE;
```

```
            if (SYMBOL_TABLE(I).DECLARATION_TYPE = DECLARE_TYPE) then
            put(ADJUST_EDIT_BUFFER(NAME, SIZE));
            put(COUNT, 5); new_line;
               SCREEN_COUNTER := SCREEN_COUNTER + 1;
               if (SCREEN_COUNTER = 10) then
                  new_line(3);
                  put("       ---  Enter 'S' to stop or any other letter to");
                  put(" continue ---");
                  new_line;
                  get(HOLD_CHARACTER);
                  if (HOLD_CHARACTER = 'S') or (HOLD_CHARACTER = 's') then
                     SKIP := TRUE;
                  end if;
                  CLEARSCREEN;
                  case DECLARE_TYPE is
                     when VARIABLE_DECLARE =>
                        put("  VARIABLES for file - ");
                     when CONSTANT_DECLARE =>
                        put("  CONSTANTS for file - ");
                     when NO_DECLARE       =>
                        put("  GLOBAL VARIABLES for file - ");
                     when others           =>  null;
                  end case;
                  put(ADJUST_LEXEME(DATA_FILE_NAME, DATA_FILE_SIZE)); new_line(2);
                  put("NAME                                               REFERENCED");
                  new_line;
                  put("---------------------------------------------------------------");
                  new_line;
                  SCREEN_COUNTER := 0;
               end if;                      -- if screen_counter = 10
            end if;                         -- if symbol_table(i).declaration_type
            if (I = LAST_ENTRY_INDEX - 1) then
               CONTINUE := TRUE;
            end if;                         -- if i = last_entry_index-1
            exit when SKIP;
         end loop;                          -- for i in 0..(last_entry_index-1)
         new_line;
         exit when ((SKIP) or (CONTINUE));
      end loop;                             -- while not skip loop
      exit when SKIP;
      new_line;
      put("                 --- Enter any letter to continue ---");
      new_line;
      get(HOLD_CHARACTER);
      CLEARSCREEN;
      SCREEN_COUNTER := 0;
   end loop;                                -- for declare_type in

   CLEARSCREEN;
   put("===================================================================");
   new_line(2);
   put(ADJUST_EDIT_BUFFER("Total number of operands used", 29));
   put(LAST_ENTRY_INDEX - 1, 5); new_line;
   put(ADJUST_EDIT_BUFFER("Total number of occurences, all operands", 40));
   put(TOTAL_OPERAND_COUNT, 5); new_line(3);
   put("                 --- Enter any letter to continue ---");
   new_line;
   get(HOLD_CHARACTER);
end VIEW_VARIABLES;

--------------------------------------------------------------------------------

   -- this procedure displays the Halstead operand metric data for
   --  tasks, and blocks.
procedure VIEW_BLOCKS is
   SCREEN_COUNTER : integer := 0;
   NAME           : string(1..LINESIZE);
   SIZE, COUNT    : integer;
   HOLD_CHARACTER : character;
```

```
begin
   CLEARSCREEN;
   put("************************************************************");
   put("***********************"); new_line(2);

   CONVERT_UPPER_CASE(DATA_FILE_NAME, DATA_FILE_SIZE);
   for DECLARE_TYPE in TASK_DECLARE..BLOCK_DECLARE loop
      case DECLARE_TYPE is
         when TASK_DECLARE =>
            put("  TASKS for file - ");
         when BLOCK_DECLARE =>
            put("  BLOCKS for file - ");
         when others           =>  null;
      end case;
      put(ADJUST_LEXEME(DATA_FILE_NAME, DATA_FILE_SIZE)); new_line(2);
      put("NAME                                            REFERENCED"); new_line;
      put("------------------------------------------------------"); new_line;

      for I in 0..(LAST_ENTRY_INDEX-1) loop
         NAME  := SYMBOL_TABLE(I).LEXEME_ADDRESS.OPERAND;
         SIZE  := SYMBOL_TABLE(I).LEXEME_ADDRESS.SIZE;
         COUNT := SYMBOL_TABLE(I).REFERENCE;
         if (SYMBOL_TABLE(I).DECLARATION_TYPE = DECLARE_TYPE) then
            put(ADJUST_EDIT_BUFFER(NAME, SIZE));
            put(COUNT, 5); new_line;
            SCREEN_COUNTER := SCREEN_COUNTER + 1;
            if (SCREEN_COUNTER = 10) then
               new_line(3);
               put("               --- Enter any letter to continue ---");
               new_line;
               get(HOLD_CHARACTER);
               CLEARSCREEN;
               SCREEN_COUNTER := 0;
               case DECLARE_TYPE is
                  when TASK_DECLARE    =>
                     put("  TASKS for file - ");
                  when BLOCK_DECLARE   =>
                     put("  BLOCKS for file - ");
                  when others          =>  null;
               end case;
               put(ADJUST_LEXEME(DATA_FILE_NAME, DATA_FILE_SIZE)); new_line(2);
               put("NAME                                            REFERENCED");
               new_line;
               put("------------------------------------------------------");
               new_line;
            end if;                         -- if screen_counter = 10
         end if;                            -- if symbol_table(i).declaration_type
      end loop;                             -- for i in 0..(last_entry_index-1)
      new_line(2);
      put("               --- Enter any letter to continue ---");
      new_line;
      get(HOLD_CHARACTER);
      CLEARSCREEN;
      SCREEN_COUNTER := 0;
   end loop;                                -- for declare_type in
end VIEW_BLOCKS;

--------------------------------------------------------------------------------

   -- this procedure calculates and displays all of the variables used in
   --  evaluation of the Halstead length metric.  The conclusions, which are
   --  determined from the calculated lengths, are based on Halstead's
   --  observations.
procedure METRIC_CONCLUSIONS is
   HOLD_CHARACTER : character;
   LITTLE_N1, LITTLE_N2, BIG_N1, BIG_N2 : integer;
   LOG_RESULT, DIFFERENCE, DISPARITY : float;
   ADD_RESULT : integer;
begin
```

```
CLEARSCREEN;
open(DATA_FILE4, in_file, DATA_FILE_NAME & ".hals");
get(DATA_FILE4, LITTLE_N1, 5);
get(DATA_FILE4, BIG_N1, 5);
get(DATA_FILE4, LITTLE_N2, 5);
get(DATA_FILE4, BIG_N2, 5);
ADD_RESULT := BIG_N1 + BIG_N2;
LOG_RESULT := (float(LITTLE_N1) * LOG2(float(LITTLE_N1))) +
                    (float(LITTLE_N2) * LOG2(float(LITTLE_N2)));
DIFFERENCE := LOG_RESULT - float(ADD_RESULT);
DISPARITY := DIFFERENCE / float(TOTAL_LINES_INPUT);

put("Definition of Halstead variables"); new_line;
put("    n1 - number of distinct operators"); new_line;
put("    n2 - number of distinct operands"); new_line;
put("    N1 - total number of occurences of operators"); new_line;
put("    N2 - total number of occurences of operands"); new_line(2);

put(ADJUST_EDIT_BUFFER("Theoretical Length n1*log(n1) + n2*log(n2);", 44));
put(LOG_RESULT, 5, 1, 0); new_line;
put(ADJUST_EDIT_BUFFER("Actual Length N1 + N2;", 23));
put(ADD_RESULT, 5); new_line(2);

put(ADJUST_EDIT_BUFFER("Difference between theoretical and actual", 41));
put(DIFFERENCE, 5, 1, 0); new_line;
put(ADJUST_EDIT_BUFFER("Disparity (Difference / Total_lines_input)", 42));
put(DISPARITY, 5, 1, 0); new_line(2);

if ((DISPARITY > 0.5) and (DISPARITY <= 1.0)) then
   put("A very large positive disparity. Reasons:"); new_line;
   put("  1 - POSSIBILITY OF OPERANDS DECLARED BUT NOT USED "); new_line;
   put("      There my be some variables which were declared "); new_line;
   put("      but never referenced in the program"); new_line;
   put("  2 - USE OF GLOBAL VARIABLES."); new_line;
   put("      A large number of the variables referenced were "); new_line;
   put("      declared in the package instantiations by the "); new_line;
   put("      WITH statements."); new_line;
elsif ((DISPARITY > 0.0) and (DISPARITY <= 0.5)) then
   put("A small positive disparity.  Reasons: "); new_line;
   put("  1 - SOME OF THE OPERANDS DECLARED WERE NOT USED "); new_line;
   put("      There my be some variables which were declared "); new_line;
   put("      but never referenced in the program"); new_line;
   put("  2 - SOME USE OF GLOBAL VARIABLES. "); new_line;
   put("      A large number of the variables referenced were "); new_line;
   put("      declared in the package instantiations by the "); new_line;
   put("      WITH statements."); new_line;
elsif ((DISPARITY > -0.5) and (DISPARITY <= 0.0)) then
   new_line;
   put("         --- Enter any character to continue ---"); new_line;
   get(HOLD_CHARACTER);
   CLEARSCREEN;
   put("A small negative disparity.  By Halstead's standards, this is ");
   put("a well polished program. "); new_line;
   put("However there may exist any of the following: "); new_line;
   put("  1 - CANCELLING OF OPERATORS "); new_line;
   put("      The occurence of an inverse cancels the effect of a ");
   put("previous operator."); new_line;
   put("  2 - AMBIGUOUS OPERANDS "); new_line;
   put("      Same operand represents two or more variables."); new_line;
   put("  3 - SYNONYMOUS OPERANDS "); new_line;
   put("      Two or more operands represent the same variable."); new_line;
   put("  4 - COMMON SUBEXPRESSION "); new_line;
   put("      The same subexpression occurs more than once. "); new_line;
   put("  5 - UNNECESSARY REPLACEMENTS "); new_line;
   put("      A subexpression is assigned to a temporary "); new_line;
   put("      variable which is used only once. "); new_line;
   put("  6 - UNFACTORED EXPRESSIONS "); new_line;
   put("      Repetitions of operators and operands among unfactored ");
   put("terms. "); new_line;
```

```
   else
      new_line;
      put("          --- Enter any character to continue ---"); new_line;
      get(HOLD_CHARACTER);
      CLEARSCREEN;
      put("A large negative disparity.  Halstead gives six reasons: "); new_line;
      put("  1 - CANCELLING OF OPERATORS "); new_line;
      put("       The occurence of an inverse cancels the effect of a ");
      put("previous operator."); new_line;
      put("  2 - AMBIGUOUS OPERANDS "); new_line;
      put("       Same operand represents two or more variables."); new_line;
      put("  3 - SYNONYMOUS OPERANDS "); new_line;
      put("       Two or more operands represent the same variable."); new_line;
      put("  4 - COMMON SUBEXPRESSION "); new_line;
      put("       The same subexpression occurs more than once. "); new_line;
      put("  5 - UNNECESSARY REPLACEMENTS "); new_line;
      put("       A subexpression is assigned to a temporary "); new_line;
      put("       variable which is used only once. "); new_line;
      put("  6 - UNFACTORED EXPRESSIONS "); new_line;
      put("       Repetitions of operators and operands among unfactored ");
      put("terms. "); new_line;
   end if;
   new_line;
   put("          --- Enter any character to continue ---"); new_line;
   get(HOLD_CHARACTER);
   close(DATA_FILE4);
end METRIC_CONCLUSIONS;

---------------------------------------------------------------------------------

   -- this function computes the log to the base 2 of a number by using
   --  natural logarithms.
function LOG2(NUMBER : float) return float is
   X, Y : float;
begin
   X := NATURAL_LOG(NUMBER);
   Y := NATURAL_LOG(2.0);
   return (X/Y);
end LOG2;

---------------------------------------------------------------------------------

   -- this function computes the natural logarithm of a number.
function NATURAL_LOG(NUMBER : float) return float is
   A     : constant array (0..5) of float
                   := (0.68629150E+00, 0.67341785E-02, 0.11894142E-03,
                         0.25009347E-05, 0.57260501E-07, 0.13791205E-08);
   XP, Y          : float;
   M              : integer;
   B0, B1, B2     : float;
begin
   XP := NUMBER;
   if (XP < 0.0) then
      raise DEVICE_ERROR;
   end if;
   M := 0;
   while (XP >= 2.0) loop
      M := M + 1;
      XP := XP/2.0;
   end loop;

   Y := 3.0 * (XP - 1.0)/(XP + 1.0);
   XP := 4.0 * Y * (Y - 2.0);
   B0 := 0.0;
   B1 := 0.0;

   for I in reverse 5..0 loop
      B2 := B1;
      B1 := B0;
```

```
      B0 := XP * B1 - B2 + A(I);
   end loop;

   return (float(M) * 0.69314718 + Y * (B0 - B1));
end NATURAL_LOG;

end HALSTEAD_DISPLAY;
```

```
--*****************************************************************--
--                                                                  --
--  TITLE:          AN ADA SOFTWARE METRIC                          --
--                                                                  --
--  MODULE NAME:    INITIAL_DISPLAY                                 --
--  DATE CREATED:   05 OCT 86                                       --
--  LAST MODIFIED:  03 DEC 86                                       --
--                                                                  --
--  AUTHORS:        LCDR JEFFREY L. NIEDER                          --
--                  LT KARL S. FAIRBANKS, JR.                       --
--                                                                  --
--  DESCRIPTION:  This package contains the procedures that        --
--       introduce the metric program and manages the data         --
--       files.                                                     --
--                                                                  --
--*****************************************************************--

with DISPLAY_SUPPORT, PARSER_0, HALSTEAD_METRIC, GLOBAL_PARSER, GLOBAL, TEXT_IO;
use DISPLAY_SUPPORT, PARSER_0, HALSTEAD_METRIC, GLOBAL_PARSER, GLOBAL, TEXT_IO;

package INITIAL_DISPLAY is
   procedure INITIAL_SCREEN;
   procedure INTRODUCTION;
end INITIAL_DISPLAY;

--------------------------------------------------------------------------------
--------------------------------------------------------------------------------

package body INITIAL_DISPLAY is

   -- this procedure opens all data files for the input file, starts the
   --  the parsing process, writes the metric data to the appropriate files,
   --  closes the data files, and prompts the user for further input files
   --  to parse.
procedure INITIAL_SCREEN is
   DONE : boolean;
begin
   FINISHED := FALSE;
   while not FINISHED loop
      DONE := FALSE;
      open(RESULT_FILE, out_file, "RESULTS.ADA");

      GET_FILENAME(TYPE_PRESENT);

      if (TYPE_PRESENT) then
         open(TEST_FILE, in_file, TEST_FILE_NAME);
         create(DATA_FILE1, out_file, DATA_FILE_NAME & ".data");
         create(DATA_FILE2, out_file, DATA_FILE_NAME & ".misc");
         create(DATA_FILE3, out_file, DATA_FILE_NAME & ".rand");
         create(DATA_FILE4, out_file, DATA_FILE_NAME & ".hals");
      else
         open(TEST_FILE, in_file, TEST_FILE_NAME & ".ada");
         create(DATA_FILE1, out_file, DATA_FILE_NAME & ".data");
         create(DATA_FILE2, out_file, DATA_FILE_NAME & ".misc");
         create(DATA_FILE3, out_file, DATA_FILE_NAME & ".rand");
         create(DATA_FILE4, out_file, DATA_FILE_NAME & ".hals");
      end if;

      INITIALIZE_OPERAND_LIST(DATA_FILE_NAME, HEAD_NODE);

      if (COMPILATION) then
         new_line;
         CLEARSCREEN;
         put("############################################");
         put("##################################"); new_line;
         put("#                                            ");
         put("                                 #"); new_line;
         put("#                       Parse of Ada program");
         put(" complete                        #"); new_line;
```

```
      put("#                                              ");
      put("                                            #"); new_line;
      put("################################################");
      put("#################################"); new_line;
   else
      put("Attempting to parse a non_compilable program");
   end if;
   new_line(3);

   WRITE_OPERATOR_TABLE(DATA_FILE1, DATA_FILE2, DATA_FILE4);

   WRITE_OPERAND_TABLE(DATA_FILE3, DATA_FILE4);

   WRITE_NESTING_TABLE(DATA_FILE2);

   close(DATA_FILE1);
   close(DATA_FILE2);
   close(DATA_FILE3);
   close(DATA_FILE4);
   close(RESULT_FILE);

   close(TEST_FILE);

   while not (DONE) loop
      new_line(2);
      put("++++++++++++++++++++++++++++++++++++++++++++++++++");
      put("+++++++++++++++++++++++++"); new_line;
      put("+                                                 ");
      put("                         +"); new_line;
      put("+          The program has completed the parse of your");
      put(" input file               +"); new_line;
      put("+                                                 ");
      put("                         +"); new_line;
      put("+              Do you want to parse another file ? (Y/");
      put("N)                       +"); new_line;
      put("+                                                 ");
      put("                         +"); new_line;
      put("+                   Type 'Y' for YES and 'N' for NO   ");
      put("                         +"); new_line;
      put("+                                              .  ");
      put("                         +"); new_line;
      put("++++++++++++++++++++++++++++++++++++++++++++++++++");
      put("+++++++++++++++++++++++++"); new_line(2);
      put("Answer : ");

      GET_ANSWER(ERROR,FINISHED);
      get_line(INPUT_FILE_NAME, LENGTH_OF_LINE);        -- flush system input
      new_line;                                         --   buffer
      RESET_PARAMETERS;

      if ERROR then
         new_line(2);
         put("||||||||||||||||||||||||||||||||||||||||||||||||||");
         put("|||||||||||||||||||||||||"); new_line;
         put("                                                  ");
         put("                         "); new_line;
         put("  You either omitted or improperly entered your 'Y'");
         put(" or 'N' answer           "); new_line;
         put("                                 Please Try Again    ");
         put("                         "); new_line;
         put("                                                  ");
         put("                         "); new_line;
         put("||||||||||||||||||||||||||||||||||||||||||||||||||");
         put("|||||||||||||||||||||||||"); new_line;
      else
         DONE := TRUE;
      end if;                                 -- if ERROR
   end loop;                                  -- while not done
end loop;                                     -- outer while loop
```

```
end INITIAL_SCREEN;

-----------------------------------------------------------------------------

   -- this procedure produces the initial screen displayed to the user.
procedure INTRODUCTION is
   HOLD_CHARACTER : character;
begin
   CLEARSCREEN;
   put("**********************************************");
   put("*********************"); new_line;
   put("*                                            ");
   put("                    *"); new_line;
   put("*                      WELCOME TO 'AdaMEASURE'  ");
   put("                    *"); new_line;
   put("*                                            ");
   put("                    *"); new_line;
   put("*             AUTHORED BY: LCDR JEFFREY L. NIEDER");
   put(", USN               *"); new_line;
   put("*                         LT   KARL S. FAIRBANKS");
   put(", USN               *"); new_line;
   put("*                                            ");
   put("                    *"); new_line;
   put("*                      NAVAL POSTGRADUATE SCHOOL");
   put("                    *"); new_line;
   put("*                   DEPARTMENT OF COMPUTER SCIEN");
   put("CE                  *"); new_line;
   put("*                        MONTEREY, CALIFORNIA   ");
   put("                    *"); new_line;
   put("*                                            ");
   put("                    *"); new_line;
   put("*                          31 OCTOBER 1986      ");
   put("                    *"); new_line;
   put("*                                            ");
   put("                    *"); new_line;
   put("*                            VERSION 1.0       ");
   put("                    *"); new_line;
   put("*                                            ");
   put("                    *"); new_line;
   put("* This program provides an automated  software ");
   put("metric  tool  which *"); new_line;
   put("* uses quantitative measures in an effort to su");
   put("pply the user  with *"); new_line;
   put("* helpful information about the static structur");
   put("e of  a given input *"); new_line;
   put("* program.  This program is public domain infor");
   put("mation.             *"); new_line;
   put("*                                            ");
   put("                    *"); new_line;
   put("**********************************************");
   put("*********************"); new_line(2);
   put("                  --- Enter any letter to continue ---");
   new_line;
   get(HOLD_CHARACTER);
end INTRODUCTION;

end INITIAL_DISPLAY;
```

```
--**********************************************************--
--                                                          --
--  TITLE:          AN ADA SOFTWARE METRIC                  --
--                                                          --
--  MODULE NAME:    PACKAGE LOW_LEVEL_SCANNER               --
--  DATE CREATED:   06 JUN 86                               --
--  LAST MODIFIED:  04 NOV 86                               --
--                                                          --
--  AUTHORS:        LCDR JEFFREY L. NIEDER                  --
--                  LT KARL S. FAIRBANKS, JR.               --
--                                                          --
--  DESCRIPTION:  This package contains six of the seven    --
--       procedures used to identify the token types.  The  --
--       seventh procedure, used to identify numeric literals  --
--       is contained in package NUMERIC.                   --
--                                                          --
--**********************************************************--

with NUMERIC, GET_NEXT_CHARACTER, GLOBAL;
use NUMERIC, GET_NEXT_CHARACTER, GLOBAL;

package LOW_LEVEL_SCANNER is
   procedure GET_IDENTIFIER(TOKEN_RECORD: in out TOKEN_RECORD_TYPE);
   procedure FLUSH_SEPARATORS(TOKEN_RECORD:  in out TOKEN_RECORD_TYPE);
   procedure GET_DELIMITER(TOKEN_RECORD:  in out TOKEN_RECORD_TYPE);
   procedure FLUSH_COMMENT(TOKEN_RECORD:  in out TOKEN_RECORD_TYPE);
   procedure GET_CHARACTER_LIT(TOKEN_RECORD:  in out TOKEN_RECORD_TYPE));
   procedure GET_STRING_LIT(TOKEN_RECORD:  in out TOKEN_RECORD_TYPE);
end LOW_LEVEL_SCANNER;

-----------------------------------------------------------------------------
-----------------------------------------------------------------------------

package body LOW_LEVEL_SCANNER is

-- an identifier can be any number of letters or digits following the
-- first letter, with a single underscore allowed between any pair
-- of letters and/or digits

procedure GET_IDENTIFIER(TOKEN_RECORD : in out TOKEN_RECORD_TYPE) is
   DONE : boolean := FALSE;
begin
   while (not DONE) loop
        -- store the character in the lexeme buffer
        -- and increment the lexeme pointer
      TOKEN_RECORD.LEXEME(LEXEME_LENGTH) := NEXT_CHARACTER;
      LEXEME_LENGTH := LEXEME_LENGTH + 1;

      if ((LOOKAHEAD_ONE_CHARACTER in UPPER_CASE_LETTER) or
         (LOOKAHEAD_ONE_CHARACTER in LOWER_CASE_LETTER) or
         (LOOKAHEAD_ONE_CHARACTER in DIGITS_TYPE)) then
         GETNEXTCHARACTER(NEXT_CHARACTER, LOOKAHEAD_ONE_CHARACTER);

      elsif ((LOOKAHEAD_ONE_CHARACTER = '_') and (NEXT_CHARACTER = '_')) then
         ERROR_MESSAGE(TOKEN_RECORD.TOKEN_TYPE);  -- two consecutive underscores
                                                             -- are not allowed
      elsif (LOOKAHEAD_ONE_CHARACTER = '_') then
         GETNEXTCHARACTER(NEXT_CHARACTER, LOOKAHEAD_ONE_CHARACTER);

      else
         DONE := TRUE;    -- identifier token accepted
      end if;
   end loop;
end GET_IDENTIFIER;

-----------------------------------------------------------------------------

-- this procedure removes all the separators, which are delineated
--   in GLOBAL, from the input code
```

```
procedure FLUSH_SEPARATORS(TOKEN_RECORD : in out TOKEN_RECORD_TYPE) is
   DONE : boolean := FALSE;
begin
   while (not DONE) loop
      TOKEN_RECORD.LEXEME(LEXEME_LENGTH) := NEXT_CHARACTER;
      LEXEME_LENGTH := LEXEME_LENGTH + 1;
      if ((LOOKAHEAD_ONE_CHARACTER = ' ') or
       ((character'pos(LOOKAHEAD_ONE_CHARACTER) in FORMATORS) and
       (LOOKAHEAD_ONE_CHARACTER /= ASCII.CR))) then
         GETNEXTCHARACTER(NEXT_CHARACTER, LOOKAHEAD_ONE_CHARACTER);
      else
         DONE := TRUE;  -- completed flushing of separators
      end if;
   end loop;
end FLUSH_SEPARATORS;

-------------------------------------------------------------------------------

-- this procedure identifies both the simple and compound delimiters
--   which are delineated in GLOBAL

procedure GET_DELIMITER(TOKEN_RECORD : in out TOKEN_RECORD_TYPE) is
begin
        -- store the character in the lexeme buffer
        -- and increment the lexeme pointer
   TOKEN_RECORD.LEXEME(LEXEME_LENGTH) := NEXT_CHARACTER;
   LEXEME_LENGTH := LEXEME_LENGTH + 1;

   if ((character'pos(NEXT_CHARACTER) in COMPOUND_DELIMITER) or
      (NEXT_CHARACTER = '.') or (NEXT_CHARACTER = '*') or
      (NEXT_CHARACTER = ':') or (NEXT_CHARACTER = '/')) then

      if ((character'pos(LOOKAHEAD_ONE_CHARACTER) in COMPOUND_DELIMITER) or
         (LOOKAHEAD_ONE_CHARACTER = '.') or (LOOKAHEAD_ONE_CHARACTER = '*')) then
         GETNEXTCHARACTER(NEXT_CHARACTER, LOOKAHEAD_ONE_CHARACTER);
         TOKEN_RECORD.LEXEME(LEXEME_LENGTH) := NEXT_CHARACTER;
         LEXEME_LENGTH := LEXEME_LENGTH + 1;
      end if;
   end if;
end GET_DELIMITER;

-------------------------------------------------------------------------------

-- this procedure removes all the comments from the input code
--   all comments start with a -- and end with a carriage return

procedure FLUSH_COMMENT(TOKEN_RECORD : in out TOKEN_RECORD_TYPE) is
   DONE : boolean := FALSE;
begin
   GETNEXTCHARACTER(NEXT_CHARACTER, LOOKAHEAD_ONE_CHARACTER);
   while (not DONE) loop
      if (LOOKAHEAD_ONE_CHARACTER = ASCII.CR) then
         DONE := TRUE;  -- end of comment
      else
         GETNEXTCHARACTER(NEXT_CHARACTER, LOOKAHEAD_ONE_CHARACTER);
      end if;
   end loop;
end FLUSH_COMMENT;

-------------------------------------------------------------------------------

-- this procedure identifies an individual character
--   formators are not allowed to be character literals

procedure GET_CHARACTER_LIT(TOKEN_RECORD : in out TOKEN_RECORD_TYPE) is
   STATE : positive := 1;
   DONE : boolean := FALSE;
begin
```

```
   while (not DONE) loop
      case STATE is
                          -- store the character in the lexeme buffer
                          -- and increment the lexeme pointer
         when 1 =>  TOKEN_RECORD.LEXEME(LEXEME_LENGTH) := NEXT_CHARACTER;
                       LEXEME_LENGTH := LEXEME_LENGTH + 1;

                       if (LOOKAHEAD_ONE_CHARACTER = ''') then
                          STATE := 2;
                          GETNEXTCHARACTER(NEXT_CHARACTER, LOOKAHEAD_ONE_CHARACTER);
                       elsif (character'pos(LOOKAHEAD_ONE_CHARACTER)
                          in FORMATORS) then
                          ERROR_MESSAGE(TOKEN_RECORD.TOKEN_TYPE);
                       else
                          STATE := 2;
                          GETNEXTCHARACTER(NEXT_CHARACTER, LOOKAHEAD_ONE_CHARACTER);
                       end if;

         when 2 =>  if (LOOKAHEAD_ONE_CHARACTER = ''') then
                             -- store the character in the lexeme buffer
                             -- and increment the lexeme pointer
                          TOKEN_RECORD.LEXEME(LEXEME_LENGTH) := NEXT_CHARACTER;
                          LEXEME_LENGTH := LEXEME_LENGTH + 1;
                          GETNEXTCHARACTER(NEXT_CHARACTER, LOOKAHEAD_ONE_CHARACTER);
                          TOKEN_RECORD.LEXEME(LEXEME_LENGTH) := NEXT_CHARACTER;

                       else
                        -- one single quote found, classify as accent mark
                        --  change token type from character literal to delimiter
                          TOKEN_RECORD.TOKEN_TYPE := DELIMITER;
                          NEXT_BUFFER_INDEX := CURRENT_BUFFER_INDEX;
                       end if;
                       DONE := TRUE;

         when others => null;
      end case;
   end loop;
end GET_CHARACTER_LIT;

-----------------------------------------------------------------------------

-- this procedure identifies a string which is a sequence of zero or
--   more characters between double quotes

procedure GET_STRING_LIT(TOKEN_RECORD : in out TOKEN_RECORD_TYPE)is
   STATE : positive := 1;
   DONE : boolean := FALSE;
begin
   while (not DONE) loop
        -- store the character in the lexeme buffer
        -- and increment the lexeme pointer
      TOKEN_RECORD.LEXEME(LEXEME_LENGTH) := NEXT_CHARACTER;
      LEXEME_LENGTH := LEXEME_LENGTH + 1;

      case STATE is
         when 1 =>  if (LOOKAHEAD_ONE_CHARACTER = '"') then
                          STATE := 2;   -- two consecutive quotes seen
                       else
                          STATE := 4;   -- one or more characters in the string
                       end if;
                       GETNEXTCHARACTER(NEXT_CHARACTER, LOOKAHEAD_ONE_CHARACTER);

         when 2 =>  if (LOOKAHEAD_ONE_CHARACTER = '"') then
                          STATE := 3;               -- three consecutive quotes seen
                          GETNEXTCHARACTER(NEXT_CHARACTER, LOOKAHEAD_ONE_CHARACTER);
                       else
                          DONE := TRUE;   -- string of zero characters accepted
                       end if;
```

```
         when 3 =>  if (LOOKAHEAD_ONE_CHARACTER = '"') then
                       GETNEXTCHARACTER(NEXT_CHARACTER, LOOKAHEAD_ONE_CHARACTER);
                       TOKEN_RECORD.LEXEME(LEXEME_LENGTH) := NEXT_CHARACTER;
                       LEXEME_LENGTH := LEXEME_LENGTH + 1;
                       DONE := TRUE;  -- four consecutive quotes
                                      -- string of one printable quote accepted
                    else
                       STATE := 4;
                       GETNEXTCHARACTER(NEXT_CHARACTER, LOOKAHEAD_ONE_CHARACTER);
                    end if;

         when 4 =>  if (LOOKAHEAD_ONE_CHARACTER = '"') then
                       STATE := 5;
                       GETNEXTCHARACTER(NEXT_CHARACTER, LOOKAHEAD_ONE_CHARACTER);
                    elsif (character'pos(NEXT_CHARACTER) in FORMATORS) then
                       ERROR_MESSAGE(TOKEN_RECORD.TOKEN_TYPE);
                    else
                       GETNEXTCHARACTER(NEXT_CHARACTER, LOOKAHEAD_ONE_CHARACTER);
                    end if;

         when 5 =>  if (LOOKAHEAD_ONE_CHARACTER = '"') then
                       STATE := 6;
                       GETNEXTCHARACTER(NEXT_CHARACTER, LOOKAHEAD_ONE_CHARACTER);
                    else
                       DONE := TRUE;      -- string literal accepted
                    end if;

         when 6 =>  if (LOOKAHEAD_ONE_CHARACTER = '"') then
                       STATE := 5;
                       GETNEXTCHARACTER(NEXT_CHARACTER, LOOKAHEAD_ONE_CHARACTER);
                    else
                       STATE := 4;
                       GETNEXTCHARACTER(NEXT_CHARACTER, LOOKAHEAD_ONE_CHARACTER);
                    end if;

         when others => null;
      end case;
   end loop;
end GET_STRING_LIT;

end LOW_LEVEL_SCANNER;
```

```
--******************************************************--
--                                                    --
--  TITLE:          AN ADA SOFTWARE METRIC            --
--                                                    --
--  MODULE NAME:    MENU_DISPLAY                      --
--  DATE CREATED:   11 OCT 86                         --
--  LAST MODIFIED:  01 DEC 86                         --
--                                                    --
--  AUTHORS:        LCDR JEFFREY L. NIEDER            --
--                  LT KARL S. FAIRBANKS, JR.         --
--                                                    --
--  DESCRIPTION:  This package contains the procedures that  --
--       produce the menus which allow the user to select a  --
--       specific 'AdaMeasure' operation.             --
--                                                    --
--******************************************************--

with GENERAL_DATA, HALSTEAD_DISPLAY, INITIAL_DISPLAY, DISPLAY_SUPPORT,
       GLOBAL_PARSER, GLOBAL, TEXT_IO;
use GENERAL_DATA, HALSTEAD_DISPLAY, INITIAL_DISPLAY, DISPLAY_SUPPORT,
      GLOBAL_PARSER, GLOBAL, TEXT_IO;

package MENU_DISPLAY is
   procedure MENU;
   procedure INITIAL_MENU;
   procedure VIEW_HENRY;
end MENU_DISPLAY;

--------------------------------------------------------------------------------
--------------------------------------------------------------------------------

package body MENU_DISPLAY is

   -- this procedure displays the metric selection menu from which the user
   --  can make the appropriate selection.
procedure MENU is
   DONE : boolean := FALSE;
begin
   while not DONE loop
      CLEARSCREEN;
      new_line;
      put("*******************************************************");
      put("**********************"); new_line;
      put("*                                                      ");
      put("                          *"); new_line;
      put("*                           METRIC SELECTION MENU      ");
      put("                          *"); new_line;
      put("*                                                      ");
      put("                          *"); new_line;
      put("*                 HERE ARE THE INFORMATION CHOICES AVAILABLE");
      put(" TO YOU                   *"); new_line;
      put("*                                                      ");
      put("                          *"); new_line;
      put("*                     Simply enter the number of your choice");
      put("                          *"); new_line;
      put("*                                                      ");
      put("                          *"); new_line;
      put("*                 1 - 'HALSTEAD' METRIC INFORMATION     ");
      put("                          *"); new_line;
      put("*                                                      ");
      put("                          *"); new_line;
      put("*                 2 - COMMENT AND NESTING METRIC INFORMATION");
      put("                          *"); new_line;
      put("*                                                      ");
      put("                          *"); new_line;
      put("*                 3 - 'HENRY and KAFURA' METRIC INFORMATION ");
      put("                          *"); new_line;
      put("*                                                      ");
      put("                          *"); new_line;
```

```
      put("*              4 - EXIT TO MAIN MENU                    ");
      put("                         *"); new_line;
      put("*                                                        ");
      put("                         *"); new_line;
      put("*              5 - EXIT TO OPERATING SYSTEM             ");
      put("                         *"); new_line;
      put("*                                                        ");
      put("                         *"); new_line;
      put("******************************************************");
      put("***********************"); new_line(2);
      put("Choice = ");
      get(ANSWER);
      get_line(DUMMY_FILE_NAME, LENGTH_OF_LINE);  -- flush system input buffer
      new_line(2);
      case ANSWER is
         when '1' => HALSTEAD;
         when '2' => VIEW_GENERAL;
         when '3' => VIEW_HENRY;
         when '4' => DONE := TRUE;
         when '5' => raise QUIT_TO_OS;
         when others => null;
      end case;
   end loop;
end MENU;

-------------------------------------------------------------------------------

   -- this procedure displays the main selection menu which allows the user
   --  to choose to parse a file, view previously gathered data, or quit to
   --  the operating system.
procedure INITIAL_MENU is
   DONE : boolean := FALSE;
begin
   INTRODUCTION;
   while not DONE loop
      CLEARSCREEN;
      new_line;
      put("******************************************************");
      put("***********************"); new_line;
      put("*                                                        ");
      put("                         *"); new_line;
      put("*                        MAIN SELECTION MENU          ");
      put("                         *"); new_line;
      put("*                                                        ");
      put("                         *"); new_line;
      put("*             HERE ARE THE ACTION CHOICES AVAILABLE TO ");
      put("YOU                      *"); new_line;
      put("*                                                        ");
      put("                         *"); new_line;
      put("*                Simply enter the number of your choice");
      put("                         *"); new_line;
      put("*                                                        ");
      put("                         *"); new_line;
      put("*              1 - PARSE AN INPUT FILE                  ");
      put("                         *"); new_line;
      put("*                                                        ");
      put("                         *"); new_line;
      put("*              2 - VIEW PREVIOUSLY GATHERED DATA        ");
      put("                         *"); new_line;
      put("*                                                        ");
      put("                         *"); new_line;
      put("*              3 - EXIT TO OPERATING SYSTEM             ");
      put("                         *"); new_line;
      put("*                                                        ");
      put("                         *"); new_line;
      put("******************************************************");
      put("***********************"); new_line(2);
      put("Choice = ");
      get(ANSWER);
```

```
      get_line(DUMMY_FILE_NAME, LENGTH_OF_LINE);  -- flush system input buffer
      new_line(2);
      case ANSWER is
         when '1' => RESET_PARAMETERS;
                     INITIAL_SCREEN;
                     MENU;
         when '2' => MENU;
         when '3' => raise QUIT_TO_OS;
         when others => null;
      end case;
   end loop;
end INITIAL_MENU;

-------------------------------------------------------------------------------

   -- this procedure is just a placeholder for the implementation of the
   --  Henry and Kafura complexity flow metric.
procedure VIEW_HENRY is
   HOLD_CHARACTER : character;
begin
   CLEARSCREEN;
   new_line;
   put("================================================================");
   new_line(2);
   put("This software metric has not yet been implemented into this");
   new_line;
   put("program. It is hoped that this information will be added in");
   new_line;
   put("the very near future.");
   new_line(2);
   put("================================================================");
   new_line(2);
   put("           --- Enter any letter to continue ---");
   new_line;
   get(HOLD_CHARACTER);
end VIEW_HENRY;

end MENU_DISPLAY;
```

APPENDIX D

'ADAMEASURE' PROGRAM LISTING - PART 2

```
--*************************************************************--
--                                                             --
--  TITLE:          AN ADA SOFTWARE METRIC                     --
--                                                             --
--  MODULE NAME:    PACKAGE HALSTEAD_METRIC                    --
--  DATE CREATED:   04 OCT 86                                  --
--  LAST MODIFIED:  01 DEC 86                                  --
--                                                             --
--  AUTHORS:        LCDR JEFFREY L. NIEDER                     --
--                  LT KARL S. FAIRBANKS, JR.                  --
--                                                             --
--  DESCRIPTION:  This package contains all of the declarations --
--       and data structures required by our metric, as well as --
--       all necessary procedures and functions for gathering   --
--       and storing the metric data.                           --
--                                                             --
--*************************************************************--

with GLOBAL, GLOBAL_PARSER, BYPASS_SUPPORT_FUNCTIONS, TEXT_IO;
use GLOBAL, GLOBAL_PARSER, BYPASS_SUPPORT_FUNCTIONS, TEXT_IO;

package HALSTEAD_METRIC is
   package NEW_INTEGER_IO is new TEXT_IO.INTEGER_IO(integer);
   use NEW_INTEGER_IO;

   SCOPE_ON               : constant boolean := TRUE;
   SCOPE_OFF              : constant boolean := FALSE;

   PACKAGE_DECLARE        : constant integer := 0;
   PROCEDURE_DECLARE      : constant integer := 1;
   FUNCTION_DECLARE       : constant integer := 2;
   TASK_DECLARE           : constant integer := 3;
   BLOCK_DECLARE          : constant integer := 4;
   VARIABLE_DECLARE       : constant integer := 5;
   CONSTANT_DECLARE       : constant integer := 6;
   NO_DECLARE             : constant integer := 7;

   IF_CONSTRUCT           : constant integer := 0;
   LOOP_CONSTRUCT         : constant integer := 1;
   WHILE_CONSTRUCT        : constant integer := 2;
   FOR_CONSTRUCT          : constant integer := 3;
   CASE_CONSTRUCT         : constant integer := 4;
   IF_END                 : constant integer := 5;
   LOOP_END               : constant integer := 6;
   CASE_END               : constant integer := 7;

   NUMBER_OF_OPERANDS     : constant integer := 500;
   FIRST_LEVEL_NEST       : constant integer := 1;
   MAXIMUM_NESTING        : constant integer := 15;

   type OPERATOR_ARRAY_TYPE is
      array (TOKEN_AND..TOKEN_ASSIGNMENT) of integer;

   type OPERAND_TYPE;
   type LINK is access OPERAND_TYPE;
   type OPERAND_TYPE is
      record
         OPERAND          : string(1..LINESIZE);
         SIZE             : natural;
         NEXT_OPERAND     : LINK;
      end record;
```

```
      type OPERAND_MATRIX is
         record
            SCOPE               : integer;
            REFERENCE           : integer := 0;
            DECLARATION_TYPE    : integer;
            LEXEME_ADDRESS      : LINK;
         end record;

      type HALSTEAD_OPERAND_ARRAY is
         array(0..NUMBER_OF_OPERANDS) of OPERAND_MATRIX;

      type NESTED_COUNT_TYPE is
         array(FIRST_LEVEL_NEST..MAXIMUM_NESTING) of integer;

      type CONSTRUCT_COUNT_TYPE is
         array(IF_CONSTRUCT..CASE_CONSTRUCT) of integer;

      OPERATOR_ARRAY : OPERATOR_ARRAY_TYPE := (TOKEN_AND..TOKEN_ASSIGNMENT => 0);

      NESTED_COUNT : NESTED_COUNT_TYPE := (FIRST_LEVEL_NEST..MAXIMUM_NESTING => 0);

      CONSTRUCT_COUNT : CONSTRUCT_COUNT_TYPE := (IF_CONSTRUCT..CASE_CONSTRUCT => 0);

      SYMBOL_TABLE            : HALSTEAD_OPERAND_ARRAY;
      HEAD_NODE, NEW_NODE     : LINK;

      DECLARE_TYPE            : integer := VARIABLE_DECLARE;
      CURRENT_NESTING_LEVEL   : integer := 0;
      MAXIMUM_NESTING_LEVEL   : integer := 0;
      TOTAL_OPERAND_COUNT     : integer := 0;
      NESTING_LINE_NUMBER     : integer := 0;
      SYMBOL_TABLE_INDEX      : integer := 0;
      SCOPE_LEVEL             : integer;
      LAST_ENTRY_INDEX        : integer;

      NESTED_LEVEL_INCREASE   : boolean := TRUE;
      NO_ITERATION            : boolean := TRUE;


      procedure OPERATOR_METRIC(OPERATOR_INDEX : in integer;
                                CONSUME, RESERVE_WORD_TEST : in boolean);
      procedure OPERAND_METRIC(HEAD_NODE : in out LINK;
                               LEXEME_RECORD : in out TOKEN_RECORD_TYPE;
                               DECLARE_TYPE : in integer);
      procedure INITIALIZE_OPERAND_LIST(DATA_FILE_NAME : in out string;
                                        HEAD_NODE : in out LINK);
      procedure ADD_SYMBOL(TEMP_NODE : in out LINK; DECLARE_TYPE : in integer);
      function DUPLICATE_LEXEME(TEMP_NODE : in LINK) return boolean;
      procedure REFERENCE_UPDATE(SYMBOL_TABLE_INDEX : in out integer);
      procedure WRITE_OPERATOR_TABLE(OUTPUT1, OUTPUT2, OUTPUT3 : in out file_type);
      procedure WRITE_OPERAND_TABLE(OUTPUT1, OUTPUT2 : in out file_type);
      procedure NESTING_METRIC(NEST_TYPE : in integer);
      procedure WRITE_NESTING_TABLE(OUTPUT_FILE : in out file_type);
   end HALSTEAD_METRIC;

   ---------------------------------------------------------------------------
   ---------------------------------------------------------------------------

   package body HALSTEAD_METRIC is

      -- this procedure updates the operator array based on the parsing of a
      --  valid Halstead operator.
   procedure OPERATOR_METRIC(OPERATOR_INDEX : in integer;
                             CONSUME, RESERVE_WORD_TEST : in boolean) is
   begin
      if (CONSUME) and then not (RESERVE_WORD_TEST) then
         OPERATOR_ARRAY(OPERATOR_INDEX) := OPERATOR_ARRAY(OPERATOR_INDEX) + 1;
      end if;
```

```
end OPERATOR_METRIC;

-------------------------------------------------------------------------------

   -- this procedure builds the symbol table for the input file, and
   --  calls the appropriate procedure for entering or updating Halstead
   --  operand information.
procedure OPERAND_METRIC(HEAD_NODE : in out LINK;
                                     LEXEME_RECORD : in out TOKEN_RECORD_TYPE;
                                     DECLARE_TYPE : in integer) is
   TEMP_NODE, TRAILER : LINK;
   INPUT_LEXEME : string(1..LINESIZE);
   FOUND : boolean;
   SIZE : natural;
begin
   TRAILER := HEAD_NODE;
   TEMP_NODE := HEAD_NODE.NEXT_OPERAND;
   INPUT_LEXEME := LEXEME_RECORD.LEXEME;
   SIZE := LEXEME_RECORD.LEXEME_SIZE - 1;
   FOUND := FALSE;
   while (TEMP_NODE /= null) loop
      if (ADJUST_LEXEME(INPUT_LEXEME, SIZE) =
            ADJUST_LEXEME(TEMP_NODE.OPERAND, TEMP_NODE.SIZE)) then
         FOUND := TRUE;
      else
         TRAILER := TEMP_NODE;
         TEMP_NODE := TEMP_NODE.NEXT_OPERAND;
      end if;
      exit when FOUND;
   end loop;
   if not (FOUND) then
      NEW_NODE := new OPERAND_TYPE;
      NEW_NODE.OPERAND := INPUT_LEXEME;
      NEW_NODE.SIZE := LEXEME_RECORD.LEXEME_SIZE - 1;
      NEW_NODE.NEXT_OPERAND := null;
      TRAILER.NEXT_OPERAND := NEW_NODE;
      TEMP_NODE := NEW_NODE;
   end if;
   if not (DUPLICATE_LEXEME(TEMP_NODE)) then
      ADD_SYMBOL(TEMP_NODE, DECLARE_TYPE);
   else
      REFERENCE_UPDATE(SYMBOL_TABLE_INDEX);
   end if;
end OPERAND_METRIC;

-------------------------------------------------------------------------------

   -- this procedure initializes the head node for the symbol table.
procedure INITIALIZE_OPERAND_LIST(DATA_FILE_NAME : in out string;
                                                HEAD_NODE : in out LINK) is
begin
   HEAD_NODE := new OPERAND_TYPE;
   HEAD_NODE.OPERAND := DATA_FILE_NAME;
   HEAD_NODE.NEXT_OPERAND := null;
   SYMBOL_TABLE_INDEX := 0;
   SCOPE_LEVEL := 0;
   LAST_ENTRY_INDEX := 0;
end INITIALIZE_OPERAND_LIST;

---------------------------------------------------------------------

   -- this procedure adds all of the information about a variable when
   --  it is initially parsed.
procedure ADD_SYMBOL(TEMP_NODE : in out LINK; DECLARE_TYPE : in integer) is
begin
   SYMBOL_TABLE(LAST_ENTRY_INDEX).LEXEME_ADDRESS := TEMP_NODE;
   if (DECLARATION) then
      SYMBOL_TABLE(LAST_ENTRY_INDEX).DECLARATION := [illegible]
      SYMBOL_TABLE(LAST_ENTRY_INDEX).SCOPE := SCOPE_LEVEL;
```

AD-A177 477 ADAMEASURE: AN ADA (TRADE NAME) SOFTWARE METRIC(U) 2/2
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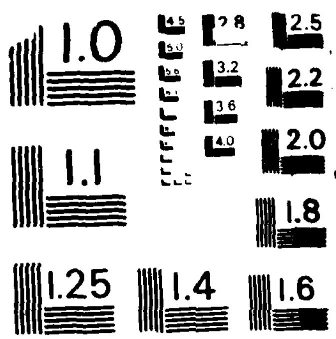

MICROCOPY RESOLUTION TEST CHART
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```
      SYMBOL_TABLE(LAST_ENTRY_INDEX).REFERENCE := 0;
   else                        -- a global variable
      if (DECLARE_TYPE = CONSTANT_DECLARE) then
         SYMBOL_TABLE(LAST_ENTRY_INDEX).DECLARATION_TYPE := CONSTANT_DECLARE;
      else
         SYMBOL_TABLE(LAST_ENTRY_INDEX).DECLARATION_TYPE := NO_DECLARE;
      end if;
      SYMBOL_TABLE(LAST_ENTRY_INDEX).SCOPE := 0;
      SYMBOL_TABLE(LAST_ENTRY_INDEX).REFERENCE := 1;
   end if;
   LAST_ENTRY_INDEX := LAST_ENTRY_INDEX + 1;
end ADD_SYMBOL;

-------------------------------------------------------------------------------

   -- this function determines if the current operand is already in the
   --  symbol table.  If located, the symbol table index is set to the
   --  appropriate position.
function DUPLICATE_LEXEME(TEMP_NODE : in LINK) return boolean is
   TEST_NAME      : string(1..LINESIZE);
   INPUT_LEXEME   : string(1..LINESIZE);
   INPUT_SIZE     : natural;
   TEST_SIZE      : natural;
   LOCATED        : boolean;
begin
   LOCATED := FALSE;
   INPUT_LEXEME := TEMP_NODE.OPERAND;
   INPUT_SIZE   := TEMP_NODE.SIZE;
   for I in 0..(LAST_ENTRY_INDEX-1) loop
      TEST_NAME := SYMBOL_TABLE(I).LEXEME_ADDRESS.OPERAND;
      TEST_SIZE := SYMBOL_TABLE(I).LEXEME_ADDRESS.SIZE;
      if (ADJUST_LEXEME(TEST_NAME, TEST_SIZE) =
            ADJUST_LEXEME(INPUT_LEXEME, INPUT_SIZE)) then
         LOCATED := TRUE;
         SYMBOL_TABLE_INDEX := I;
      end if;
      exit when LOCATED;
   end loop;
   return (LOCATED);
end DUPLICATE_LEXEME;

-------------------------------------------------------------------------------

   -- this procedure updates the reference count when an operand is parsed,
   --  after initial entry into the symbol table.
procedure REFERENCE_UPDATE(SYMBOL_TABLE_INDEX : in out integer) is
begin
   SYMBOL_TABLE(SYMBOL_TABLE_INDEX).REFERENCE :=
      SYMBOL_TABLE(SYMBOL_TABLE_INDEX).REFERENCE + 1;
   TOTAL_OPERAND_COUNT := TOTAL_OPERAND_COUNT + 1;
end REFERENCE_UPDATE;

-------------------------------------------------------------------------------

   -- this procedure writes the Halstead operator count data to the
   --  appropriate files.
procedure WRITE_OPERATOR_TABLE(OUTPUT1, OUTPUT2, OUTPUT3 : in out file_type) is
   OPERATORS_USED, OCCURENCES : integer := 0;
begin
   for I in TOKEN_AND..TOKEN_ASSIGNMENT loop
      if (OPERATOR_ARRAY(I) /= 0) then
         OPERATORS_USED := OPERATORS_USED + 1;
         OCCURENCES := OCCURENCES + OPERATOR_ARRAY(I);
      end if;
      put(OUTPUT1, OPERATOR_ARRAY(I), 5);
   end loop;
   new_line(OUTPUT1);

   for I in IF_CONSTRUCT..CASE_CONSTRUCT loop
```

```
      if (CONSTRUCT_COUNT(I) /= 0) then
         OPERATORS_USED := OPERATORS_USED + 1;
         OCCURENCES := OCCURENCES + CONSTRUCT_COUNT(I);
      end if;
      put(OUTPUT1, CONSTRUCT_COUNT(I), 5);
   end loop;

   put(OUTPUT1, OPERATORS_USED, 5);
   put(OUTPUT1, OCCURENCES, 5);

   put(OUTPUT2, TOTAL_LINES_INPUT, 5);
   put(OUTPUT2, COMMENT_COUNT, 5);

   put(OUTPUT3, OPERATORS_USED, 5);
   put(OUTPUT3, OCCURENCES, 5);

end WRITE_OPERATOR_TABLE;

-----------------------------------------------------------------------------

   -- this procedure writes the Halstead operand information to the
   --  appropriate files.
procedure WRITE_OPERAND_TABLE(OUTPUT1, OUTPUT2 : in out file_type) is
   NAME : string(1..LINESIZE);
   SIZE : integer;
begin
   put(OUTPUT1, LAST_ENTRY_INDEX - 1, 5);
   put(OUTPUT2, LAST_ENTRY_INDEX - 1, 5);
   put(OUTPUT1, TOTAL_OPERAND_COUNT, 5);
   put(OUTPUT2, TOTAL_OPERAND_COUNT, 5);
   new_line(OUTPUT1);
   for I in 0..(LAST_ENTRY_INDEX-1) loop
      NAME := SYMBOL_TABLE(I).LEXEME_ADDRESS.OPERAND;
      SIZE := SYMBOL_TABLE(I).LEXEME_ADDRESS.SIZE;
      put(OUTPUT1, SYMBOL_TABLE(I).SCOPE, 5);
      put(OUTPUT1, SYMBOL_TABLE(I).REFERENCE, 5);
      put(OUTPUT1, SYMBOL_TABLE(I).DECLARATION_TYPE, 5);
      CONVERT_UPPER_CASE(NAME, SIZE);
      put(OUTPUT1, ADJUST_LEXEME(NAME, SIZE));
      new_line(OUTPUT1);
   end loop;
end WRITE_OPERAND_TABLE;

-----------------------------------------------------------------------------

   -- this procedure maintains the maximum nesting level attained, the number
   --  of times each nesting level is reached, and the number of times each
   --  nesting construct is utilized.
procedure NESTING_METRIC(NEST_TYPE : in integer) is
begin
   case NEST_TYPE is
      when IF_CONSTRUCT   LOOP_CONSTRUCT   WHILE_CONSTRUCT
              FOR_CONSTRUCT   CASE_CONSTRUCT
              => CONSTRUCT_COUNT(NEST_TYPE) := CONSTRUCT_COUNT(NEST_TYPE) + 1;
                   NESTED_LEVEL_INCREASE := TRUE;
                   CURRENT_NESTING_LEVEL := CURRENT_NESTING_LEVEL + 1;
                   if (CURRENT_NESTING_LEVEL > MAXIMUM_NESTING_LEVEL) then
                      MAXIMUM_NESTING_LEVEL := CURRENT_NESTING_LEVEL;
                      NESTING_LINE_NUMBER := TOTAL_LINES_INPUT;
                   end if;

      when IF_END   LOOP_END   CASE_END =>
                   if (NESTED_LEVEL_INCREASE) then
                      NESTED_COUNT(CURRENT_NESTING_LEVEL) :=
                      NESTED_COUNT(CURRENT_NESTING_LEVEL) + 1;
                      NESTED_LEVEL_INCREASE := FALSE;
                   end if;
                   CURRENT_NESTING_LEVEL := CURRENT_NESTING_LEVEL - 1;
```

```
      when others => null;
   end case;
end NESTING_METRIC;

--------------------------------------------------------------------------------

   -- this procedure writes the nesting metric data to the appropriate file.
procedure WRITE_NESTING_TABLE(OUTPUT_FILE : in out file_type) is
begin
   new_line(OUTPUT_FILE);
   for I in IF_CONSTRUCT..CASE_CONSTRUCT loop
      put(OUTPUT_FILE, CONSTRUCT_COUNT(I), 5);
   end loop;
   new_line(OUTPUT_FILE);
   put(OUTPUT_FILE, MAXIMUM_NESTING_LEVEL, 5);
   new_line(OUTPUT_FILE);
   PUT(OUTPUT_FILE, NESTING_LINE_NUMBER, 5);
   new_line(OUTPUT_FILE);
   for I in FIRST_LEVEL_NEST..MAXIMUM_NESTING loop
      put(OUTPUT_FILE, NESTED_COUNT(I), 5);
   end loop;
end WRITE_NESTING_TABLE;

end HALSTEAD_METRIC;
```

```
--*********************************************************--
--                                                         --
--  TITLE:          AN ADA SOFTWARE METRIC                 --
--                                                         --
--  MODULE NAME:    PACKAGE NUMERIC                        --
--  DATE CREATED:   13 JUN 86                              --
--  LAST MODIFIED:  04 NOV 86                              --
--                                                         --
--  AUTHORS:        LCDR JEFFREY L. NIEDER                 --
--                  LT KARL S. FAIRBANKS, JR.              --
--                                                         --
--  DESCRIPTION:  This package is used to identify the following --
--       numeric types: integer, real, based integer, and  --
--       scientific notation.                              --
--                                                         --
--*********************************************************--

with GLOBAL, GET_NEXT_CHARACTER;
use GLOBAL, GET_NEXT_CHARACTER;

package NUMERIC is
   procedure GET_NUMERIC_LIT(TOKEN_RECORD : in out TOKEN_RECORD_TYPE);
end NUMERIC;

--------------------------------------------------------------------------------
--------------------------------------------------------------------------------

package body NUMERIC is

procedure GET_NUMERIC_LIT(TOKEN_RECORD : in out TOKEN_RECORD_TYPE) is
   DONE : boolean := FALSE;
   STATE : positive := 1;
begin
   while (not DONE) loop
        -- store the character in the lexeme buffer
        -- and increment the lexeme pointer
      TOKEN_RECORD.LEXEME(LEXEME_LENGTH) := NEXT_CHARACTER;
      LEXEME_LENGTH := LEXEME_LENGTH + 1;

        -- each option in the case statement is a state in the finite
        -- state automata for determining numeric literals. Ada allows
        -- the use of the underscore to aid readability of long numeric literals
      case STATE is
         when 1 =>  if (LOOKAHEAD_ONE_CHARACTER in DIGITS_TYPE) then
                       STATE := 1;
                       GETNEXTCHARACTER(NEXT_CHARACTER, LOOKAHEAD_ONE_CHARACTER);
                    elsif (LOOKAHEAD_ONE_CHARACTER = '.') then
                       STATE := 2;
                       GETNEXTCHARACTER(NEXT_CHARACTER, LOOKAHEAD_ONE_CHARACTER);
                    elsif ((LOOKAHEAD_ONE_CHARACTER = 'E') or
                       (LOOKAHEAD_ONE_CHARACTER = 'e')) then
                       STATE := 17;
                       GETNEXTCHARACTER(NEXT_CHARACTER, LOOKAHEAD_ONE_CHARACTER);
                    elsif (LOOKAHEAD_ONE_CHARACTER = '_') then
                       STATE := 9;
                       GETNEXTCHARACTER(NEXT_CHARACTER, LOOKAHEAD_ONE_CHARACTER);
                    elsif ((LOOKAHEAD_ONE_CHARACTER = '#') or
                       (LOOKAHEAD_ONE_CHARACTER = ':')) then
                       STATE := 10;
                       GETNEXTCHARACTER(NEXT_CHARACTER, LOOKAHEAD_ONE_CHARACTER);
                    elsif ((LOOKAHEAD_ONE_CHARACTER not in UPPER_CASE_LETTER) and
                       (LOOKAHEAD_ONE_CHARACTER not in LOWER_CASE_LETTER) and
                       (LOOKAHEAD_ONE_CHARACTER /= ''') and
                       (LOOKAHEAD_ONE_CHARACTER /= '"')) then

                       DONE := TRUE;          -- universal integer accepted
                    else
                       ERROR_MESSAGE(TOKEN_RECORD.TOKEN_TYPE);
                    end if;
```

```
when 2 => if (LOOKAHEAD_ONE_CHARACTER = '.') then   --test for range dots
                TOKEN_RECORD.LEXEME(LEXEME_LENGTH - 1) := ' ';
                LEXEME_LENGTH := LEXEME_LENGTH - 1;
                NEXT_BUFFER_INDEX := CURRENT_BUFFER_INDEX;

                DONE := TRUE;   -- universal integer preceded these
                                -- range dots
             elsif (LOOKAHEAD_ONE_CHARACTER in DIGITS_TYPE) then
                STATE := 3;
                GETNEXTCHARACTER(NEXT_CHARACTER, LOOKAHEAD_ONE_CHARACTER);
             else
                ERROR_MESSAGE(TOKEN_RECORD.TOKEN_TYPE);
             end if;
when 3 => if (LOOKAHEAD_ONE_CHARACTER in DIGITS_TYPE) then
                STATE := 3;
                GETNEXTCHARACTER(NEXT_CHARACTER, LOOKAHEAD_ONE_CHARACTER);
             elsif ((LOOKAHEAD_ONE_CHARACTER = 'E') or
                (LOOKAHEAD_ONE_CHARACTER = 'e')) then
                STATE := 4;
                GETNEXTCHARACTER(NEXT_CHARACTER, LOOKAHEAD_ONE_CHARACTER);
             elsif (LOOKAHEAD_ONE_CHARACTER = '_') then
                STATE := 5;
                GETNEXTCHARACTER(NEXT_CHARACTER, LOOKAHEAD_ONE_CHARACTER);
             elsif ((LOOKAHEAD_ONE_CHARACTER not in UPPER_CASE_LETTER) and
                (LOOKAHEAD_ONE_CHARACTER not in LOWER_CASE_LETTER) and
                (LOOKAHEAD_ONE_CHARACTER /= ''') and
                (LOOKAHEAD_ONE_CHARACTER /= '"')) then

                DONE := TRUE;      -- universal real accepted
             else
                ERROR_MESSAGE(TOKEN_RECORD.TOKEN_TYPE);
             end if;
when 4 => if ((LOOKAHEAD_ONE_CHARACTER = '+') or
                (LOOKAHEAD_ONE_CHARACTER = '-')) then
                STATE := 6;
                GETNEXTCHARACTER(NEXT_CHARACTER, LOOKAHEAD_ONE_CHARACTER);
             elsif (LOOKAHEAD_ONE_CHARACTER in DIGITS_TYPE) then
                STATE := 7;
                GETNEXTCHARACTER(NEXT_CHARACTER, LOOKAHEAD_ONE_CHARACTER);
             else
                ERROR_MESSAGE(TOKEN_RECORD.TOKEN_TYPE);
             end if;
when 5 6 8 9 =>
             if (LOOKAHEAD_ONE_CHARACTER in DIGITS_TYPE) then
                case STATE is
                   when  5  =>  STATE := 3;
                   when 6 8 =>  STATE := 7;
                   when  9  =>  STATE := 1;
                   when others =>  null;
                end case;
                GETNEXTCHARACTER(NEXT_CHARACTER, LOOKAHEAD_ONE_CHARACTER);
             else
                ERROR_MESSAGE(TOKEN_RECORD.TOKEN_TYPE);
             end if;
when 7 => if (LOOKAHEAD_ONE_CHARACTER in DIGITS_TYPE) then
                STATE := 7;
                GETNEXTCHARACTER(NEXT_CHARACTER, LOOKAHEAD_ONE_CHARACTER);
             elsif (LOOKAHEAD_ONE_CHARACTER = '_') then
                STATE := 8;
                GETNEXTCHARACTER(NEXT_CHARACTER, LOOKAHEAD_ONE_CHARACTER);
             elsif ((LOOKAHEAD_ONE_CHARACTER not in UPPER_CASE_LETTER) and
                (LOOKAHEAD_ONE_CHARACTER not in LOWER_CASE_LETTER) and
                (LOOKAHEAD_ONE_CHARACTER /= ''') and
                (LOOKAHEAD_ONE_CHARACTER /= '"')) then

                DONE := TRUE;   -- integer or real in scientific notation
             else
                ERROR_MESSAGE(TOKEN_RECORD.TOKEN_TYPE);
             end if;
```

```
when 10 12 14 16 =>
                 if ((LOOKAHEAD_ONE_CHARACTER in DIGITS_TYPE) or
                    (LOOKAHEAD_ONE_CHARACTER in UPPER_CASE_HEX) or
                    (LOOKAHEAD_ONE_CHARACTER in LOWER_CASE_HEX)) then
                    case STATE is
                       when 10 12 =>  STATE := 11;
                       when 14 16 =>  STATE := 15;
                       when others =>  null;
                    end case;
                    GETNEXTCHARACTER(NEXT_CHARACTER, LOOKAHEAD_ONE_CHARACTER);
                 else
                    ERROR_MESSAGE(TOKEN_RECORD.TOKEN_TYPE);
                 end if;
when 11 => if ((LOOKAHEAD_ONE_CHARACTER in DIGITS_TYPE) or
                    (LOOKAHEAD_ONE_CHARACTER in UPPER_CASE_HEX) or
                    (LOOKAHEAD_ONE_CHARACTER in LOWER_CASE_HEX)) then
                    STATE := 11;
                    GETNEXTCHARACTER(NEXT_CHARACTER, LOOKAHEAD_ONE_CHARACTER);
                 elsif (LOOKAHEAD_ONE_CHARACTER = '.') then
                    STATE := 14;
                    GETNEXTCHARACTER(NEXT_CHARACTER, LOOKAHEAD_ONE_CHARACTER);
                 elsif ((LOOKAHEAD_ONE_CHARACTER = '#') or
                    (LOOKAHEAD_ONE_CHARACTER = ':')) then
                    STATE := 13;
                    GETNEXTCHARACTER(NEXT_CHARACTER, LOOKAHEAD_ONE_CHARACTER);
                 elsif (LOOKAHEAD_ONE_CHARACTER = '_') then
                    STATE := 12;
                    GETNEXTCHARACTER(NEXT_CHARACTER, LOOKAHEAD_ONE_CHARACTER);
                 else
                    ERROR_MESSAGE(TOKEN_RECORD.TOKEN_TYPE);
                 end if;
when 13 => if ((LOOKAHEAD_ONE_CHARACTER = 'E') or
                    (LOOKAHEAD_ONE_CHARACTER = 'e')) then
                    STATE := 17;
                    GETNEXTCHARACTER(NEXT_CHARACTER, LOOKAHEAD_ONE_CHARACTER);
                 elsif ((LOOKAHEAD_ONE_CHARACTER not in UPPER_CASE_LETTER) and
                    (LOOKAHEAD_ONE_CHARACTER not in LOWER_CASE_LETTER) and
                    (LOOKAHEAD_ONE_CHARACTER /= ''') and
                    (LOOKAHEAD_ONE_CHARACTER /= '"')) then

                    DONE := TRUE;           -- based integer accepted
                 else
                    ERROR_MESSAGE(TOKEN_RECORD.TOKEN_TYPE);
                 end if;
when 15 => if ((LOOKAHEAD_ONE_CHARACTER in DIGITS_TYPE) or
                    (LOOKAHEAD_ONE_CHARACTER in UPPER_CASE_HEX) or
                    (LOOKAHEAD_ONE_CHARACTER in LOWER_CASE_HEX)) then
                    STATE := 15;
                    GETNEXTCHARACTER(NEXT_CHARACTER, LOOKAHEAD_ONE_CHARACTER);
                 elsif (LOOKAHEAD_ONE_CHARACTER = '_') then
                    STATE := 16;
                    GETNEXTCHARACTER(NEXT_CHARACTER, LOOKAHEAD_ONE_CHARACTER);
                 elsif ((LOOKAHEAD_ONE_CHARACTER = '#') or
                    (LOOKAHEAD_ONE_CHARACTER = ':')) then
                    STATE := 13;
                    GETNEXTCHARACTER(NEXT_CHARACTER, LOOKAHEAD_ONE_CHARACTER);
                 else
                    ERROR_MESSAGE(TOKEN_RECORD.TOKEN_TYPE);
                 end if;
when 17 => if (LOOKAHEAD_ONE_CHARACTER in DIGITS_TYPE) then
                    STATE := 7;
                    GETNEXTCHARACTER(NEXT_CHARACTER, LOOKAHEAD_ONE_CHARACTER);
                 elsif (LOOKAHEAD_ONE_CHARACTER = '+') then
                    STATE := 6;
                    GETNEXTCHARACTER(NEXT_CHARACTER, LOOKAHEAD_ONE_CHARACTER);
                 else
                    ERROR_MESSAGE(TOKEN_RECORD.TOKEN_TYPE);
                 end if;
when others =>  null;
```

```
      end case;
   end loop;
end GET_NUMERIC_LIT;

end NUMERIC;
```

```
--*************************************************************--
--                                                             --
--  TITLE:          AN ADA SOFTWARE METRIC                     --
--                                                             --
--  MODULE NAME:    PACKAGE PARSER_0                           --
--  DATE CREATED:   09 OCT 86                                  --
--  LAST MODIFIED:  03 DEC 86                                  --
--                                                             --
--  AUTHORS:        LCDR JEFFREY L. NIEDER                     --
--                  LT KARL S. FAIRBANKS, JR.                  --
--                                                             --
--  DESCRIPTION:  This package contains eight functions that   --
--       make up the highest level productions for our top-down, --
--       recursive descent parser.                             --
--                                                             --
--*************************************************************--

with PARSER_1, PARSER_2, PARSER_3, BYPASS_FUNCTION, HALSTEAD_METRIC,
       GLOBAL_PARSER, GLOBAL, TEXT_IO;
use PARSER_1, PARSER_2, PARSER_3, BYPASS_FUNCTION, HALSTEAD_METRIC,
      GLOBAL_PARSER, GLOBAL, TEXT_IO;

package PARSER_0 is
   function COMPILATION return boolean;
   function COMPILATION_UNIT return boolean;
   function CONTEXT_CLAUSE return boolean;
   function BASIC_UNIT return boolean;
   function LIBRARY_UNIT return boolean;
   function SECONDARY_UNIT return boolean;
   function LIBRARY_UNIT_BODY return boolean;
   function SUBUNIT return boolean;
end PARSER_0;

--------------------------------------------------------------------------------
--------------------------------------------------------------------------------

package body PARSER_0 is

   -- COMPILATION -->  [COMPILATION_UNIT]+
function COMPILATION return boolean is
begin
   put("In compilation "); new_line;
   if (COMPILATION_UNIT) then
      while (COMPILATION_UNIT) loop
         null;
      end loop;
      return (TRUE);
   else
      return (FALSE);
   end if;
end COMPILATION;

--------------------------------------------------------------------------------

   -- COMPILATION_UNIT -->  CONTEXT_CLAUSE  BASIC_UNIT
function COMPILATION_UNIT return boolean is
begin
   if (CONTEXT_CLAUSE) then
        if (BASIC_UNIT) then
             return (TRUE);
        else
             return (FALSE);
        end if;
   else
      return (FALSE);
   end if;
end COMPILATION_UNIT;

--------------------------------------------------------------------------------
```

```
   -- CONTEXT_CLAUSE -->  [with WITH_OR_USE_CLAUSE [use WITH_OR_USE_CLAUSE]* ]*
function CONTEXT_CLAUSE return boolean is
begin
   while (BYPASS(TOKEN_WITH)) loop
      if not (WITH_OR_USE_CLAUSE) then
         SYNTAX_ERROR("Context clause");
      end if;
      while (BYPASS(TOKEN_USE)) loop
         if not (WITH_OR_USE_CLAUSE) then
            SYNTAX_ERROR("Context clause");
         end if;
      end loop;                              -- inner while loop
   end loop;                                -- outer while loop
   return (TRUE);
end CONTEXT_CLAUSE;

--------------------------------------------------------------------------------

   -- BASIC_UNIT -->  LIBRARY_UNIT
   --            -->  SECONDARY_UNIT
function BASIC_UNIT return boolean is
begin
   if (LIBRARY_UNIT) then
      return (TRUE);
   elsif (SECONDARY_UNIT) then
      return (TRUE);
   else
      return (FALSE);
   end if;
end BASIC_UNIT;

--------------------------------------------------------------------------------

   -- LIBRARY_UNIT -->  procedure PROCEDURE_UNIT
   --              -->  function FUNCTION_UNIT
   --              -->  package PACKAGE_DECLARATION
   --              -->  generic GENERIC_DECLARATION
function LIBRARY_UNIT return boolean is
begin
   if (BYPASS(TOKEN_PROCEDURE)) then
      DECLARE_TYPE := PROCEDURE_DECLARE;
      if (PROCEDURE_UNIT) then
         return (TRUE);
      else
         SYNTAX_ERROR("Library unit");
      end if;                                -- if procedure_unit statement
   elsif (BYPASS(TOKEN_FUNCTION)) then
      DECLARE_TYPE := FUNCTION_DECLARE;
      if (FUNCTION_UNIT) then
         return (TRUE);
      else
         SYNTAX_ERROR("Library unit");
      end if;                                -- if function_unit statement
   elsif (BYPASS(TOKEN_PACKAGE)) then
      DECLARE_TYPE := PACKAGE_DECLARE;
      if (PACKAGE_DECLARATION) then
         return (TRUE);
      else
         SYNTAX_ERROR("Library unit");
      end if;                                -- if package_declaration
   elsif (BYPASS(TOKEN_GENERIC)) then
      if (GENERIC_DECLARATION) then
         return (TRUE);
      else
         SYNTAX_ERROR("Library unit");
      end if;                                -- if generic_declaration
   else
      return (FALSE);
```

```
   end if;
end LIBRARY_UNIT;

------------------------------------------------------------------------------

   -- SECONDARY_UNIT -->  LIBRARY_UNIT_BODY
   --                -->  SUBUNIT
function SECONDARY_UNIT return boolean is
begin
   if (LIBRARY_UNIT_BODY) then
      return (TRUE);
   elsif (SUBUNIT) then
      return (TRUE);
   else
      return (FALSE);
   end if;
end SECONDARY_UNIT;

------------------------------------------------------------------------------

   -- LIBRARY_UNIT_BODY -->  procedure PROCEDURE_UNIT
   --                   -->  function FUNCTION_UNIT
   --                   -->  package PACKAGE_DECLARATION
   --                   -->  generic GENERIC_DECLARATION
function LIBRARY_UNIT_BODY return boolean is
begin
   if (BYPASS(TOKEN_PROCEDURE)) then
      DECLARE_TYPE := PROCEDURE_DECLARE;
      if (PROCEDURE_UNIT) then
         return (TRUE);
      else
         SYNTAX_ERROR("Library unit body");
      end if;                            -- if procedure_unit statement
   elsif (BYPASS(TOKEN_FUNCTION)) then
      DECLARE_TYPE := FUNCTION_DECLARE;
      if (FUNCTION_UNIT) then
         return (TRUE);
      else
         SYNTAX_ERROR("Library unit body");
      end if;                            -- if function_unit statement
   elsif (BYPASS(TOKEN_PACKAGE)) then
      DECLARE_TYPE := PACKAGE_DECLARE;
      if (PACKAGE_DECLARATION) then
         return (TRUE);
      else
         SYNTAX_ERROR("Library unit body");
      end if;                            -- if package_declaration
   else
      return (FALSE);
   end if;                              -- if bypass(token_procedure)
end LIBRARY_UNIT_BODY;

------------------------------------------------------------------------------

   -- SUBUNIT -->  separate (NAME) PROPER_BODY
function SUBUNIT return boolean is
begin
   if (BYPASS(TOKEN_SEPARATE)) then
      if (BYPASS(TOKEN_LEFT_PAREN)) then
         if (NAME) then
            if (BYPASS(TOKEN_RIGHT_PAREN)) then
               if (PROPER_BODY) then
                  return (TRUE);
               else
                  SYNTAX_ERROR("Subunit");
               end if;                   -- if proper_body statement
            else
               SYNTAX_ERROR("Subunit");
            end if;                      -- if bypass(token_right_paren)
```

```
        else
           SYNTAX_ERROR("Subunit");
        end if;                                -- if name statement
     else
        SYNTAX_ERROR("Subunit");
     end if;                                  -- if bypass(token_left_paren)
  else
     return (FALSE);
  end if;                                    -- if bypass(token_separate)
end SUBUNIT;

end PARSER_0;
```

```
--*************************************************************--
--                                                             --
--  TITLE:          AN ADA SOFTWARE METRIC                     --
--                                                             --
--  MODULE NAME:    PACKAGE PARSER_1                           --
--  DATE CREATED:   17 JUL 86                                  --
--  LAST MODIFIED:  03 DEC 86                                  --
--                                                             --
--  AUTHORS:        LCDR JEFFREY L. NIEDER                     --
--                  LT KARL S. FAIRBANKS, JR.                  --
--                                                             --
--  DESCRIPTION:  This package contains thirty-six functions   --
--       that make up the top level productions for our top-down,--
--       recursive descent parser. Each function is preceded   --
--       by the grammar productions they are implementing.     --
--                                                             --
--*************************************************************--

with PARSER_2, PARSER_3, BYPASS_FUNCTION, HALSTEAD_METRIC, GLOBAL_PARSER,
      GLOBAL;
use PARSER_2, PARSER_3, BYPASS_FUNCTION, HALSTEAD_METRIC, GLOBAL_PARSER,
     GLOBAL;

package PARSER_1 is
   function GENERIC_DECLARATION return boolean;
   function GENERIC_PARAMETER_DECLARATION return boolean;
   function GENERIC_FORMAL_PART return boolean;
   function PROCEDURE_UNIT return boolean;
   function SUBPROGRAM_BODY return boolean;
   function FUNCTION_UNIT return boolean;
   function FUNCTION_UNIT_TAIL return boolean;
   function FUNCTION_BODY return boolean;
   function FUNCTION_BODY_TAIL return boolean;
   function TASK_DECLARATION return boolean;
   function TASK_BODY return boolean;
   function TASK_BODY_TAIL return boolean;
   function PACKAGE_DECLARATION return boolean;
   function PACKAGE_UNIT return boolean;
   function PACKAGE_BODY return boolean;
   function PACKAGE_BODY_TAIL return boolean;
   function PACKAGE_TAIL_END return boolean;
   function DECLARATIVE_PART return boolean;
   function BASIC_DECLARATIVE_ITEM return boolean;
   function BASIC_DECLARATION return boolean;
   function LATER_DECLARATIVE_ITEM return boolean;
   function PROPER_BODY return boolean;
   function SEQUENCE_OF_STATEMENTS return boolean;
   function STATEMENT return boolean;
   function COMPOUND_STATEMENT return boolean;
   function BLOCK_STATEMENT return boolean;
   function IF_STATEMENT return boolean;
   function CASE_STATEMENT return boolean;
   function CASE_STATEMENT_ALTERNATIVE return boolean;
   function LOOP_STATEMENT return boolean;
   function EXCEPTION_HANDLER return boolean;
   function ACCEPT_STATEMENT return boolean;
   function SELECT_STATEMENT return boolean;
   function SELECT_STATEMENT_TAIL return boolean;
   function SELECT_ALTERNATIVE return boolean;
   function SELECT_ENTRY_CALL return boolean;
end PARSER_1;

-------------------------------------------------------------------------------
-------------------------------------------------------------------------------

package body PARSER_1 is

   -- GENERIC_DECLARATION --> [GENERIC_PARAMETER_DECLARATION ?]
   --                              GENERIC_FORMAL_PART
```

```
function GENERIC_DECLARATION return boolean is
begin
   if (GENERIC_PARAMETER_DECLARATION) then
      null;
   end if;
   if (GENERIC_FORMAL_PART) then
      return(TRUE);
   else
      return (FALSE);
   end if;
end GENERIC_DECLARATION;

--------------------------------------------------------------------------------

   -- GENERIC_PARAMETER_DECLARATION --> IDENTIFIER_LIST : [MODE ?] NAME
   --                                     [:= EXPRESSION ?] ;
   --                               --> type private [DISCRIMINANT_PART ?]
   --                                     is PRIVATE_TYPE_DECLARATION ;
   --                               --> type private [DISCRIMINANT_PART ?]
   --                                     is GENERIC_TYPE_DEFINITION ;
   --                               --> with procedure PROCEDURE_UNIT
   --                               --> with function FUNCTION_UNIT
function GENERIC_PARAMETER_DECLARATION return boolean is
begin
   if (IDENTIFIER_LIST) then
      if (BYPASS(TOKEN_COLON)) then
         if (MODE) then
            null;
         end if;                           -- if mode statement
         if (NAME) then                    -- check for type_mark
            if (BYPASS(TOKEN_ASSIGNMENT)) then
               if (EXPRESSION) then
                  null;
               else
                  SYNTAX_ERROR("Generic parameter declaration");
               end if;                        -- if expression statement
            end if;                        -- if bypass(token_assignment)
            if (BYPASS(TOKEN_SEMICOLON)) then
               return (TRUE);
            else
               SYNTAX_ERROR("Generic parameter declaration");
            end if;                        -- if bypass(token_semicolon)
         else
            SYNTAX_ERROR("Generic parameter declaration");
         end if;                           -- if type_mark statement
      else
         SYNTAX_ERROR("Generic parameter declaration");
      end if;                              -- if bypass(token_colon)
   elsif (BYPASS(TOKEN_TYPE)) then
      if (BYPASS(TOKEN_IDENTIFIER)) then
         if (DISCRIMINANT_PART) then
            null;
         end if;                           -- if discriminant_part
         if (BYPASS(TOKEN_IS)) then
            if (PRIVATE_TYPE_DECLARATION) then
               if (BYPASS(TOKEN_SEMICOLON)) then
                  return (TRUE);
               else
                  SYNTAX_ERROR("Generic parameter declaration");
               end if;                        -- if bypass(token_semicolon)
            elsif (GENERIC_TYPE_DEFINITION) then
               if (BYPASS(TOKEN_SEMICOLON)) then
                  return (TRUE);
               else
                  SYNTAX_ERROR("Generic parameter declaration");
               end if;                        -- if bypass(token_semicolon)
            else
               SYNTAX_ERROR("Generic parameter declaration");
            end if;                        -- if private_type_declaration
```

```
         else
            SYNTAX_ERROR("Generic parameter declaration");
         end if;                              -- if bypass(token_is)
      else
         SYNTAX_ERROR("Generic parameter declaration");
      end if;                                 -- if bypass(token_identifier)
   elsif (BYPASS(TOKEN_WITH)) then
      if (BYPASS(TOKEN_PROCEDURE)) then
         DECLARE_TYPE := PROCEDURE_DECLARE;
         if (PROCEDURE_UNIT) then
            return (TRUE);
         else
            SYNTAX_ERROR("Generic parameter declaration");
         end if;                              -- if procedure_unit statement
      elsif (BYPASS(TOKEN_FUNCTION)) then
         DECLARE_TYPE := FUNCTION_DECLARE;
         if (FUNCTION_UNIT) then
            return (TRUE);
         else
            SYNTAX_ERROR("Generic parameter declaration");
         end if;                              -- if function_unit statement
      else
         SYNTAX_ERROR("Generic parameter declaration");
      end if;                                 -- if bypass(token_procedure)
   else
      return (FALSE);
   end if;                                    -- if identifier_list
end GENERIC_PARAMETER_DECLARATION;

--------------------------------------------------------------------------------

   -- GENERIC_FORMAL_PART -->  procedure PROCEDURE_UNIT
   --                     -->  function FUNCTION_UNIT
   --                     -->  package PACKAGE_DECLARATION
function GENERIC_FORMAL_PART return boolean is
begin
   if (BYPASS(TOKEN_PROCEDURE)) then
      DECLARE_TYPE := PROCEDURE_DECLARE;
      if (PROCEDURE_UNIT) then
         return (TRUE);
      else
         SYNTAX_ERROR("Generic formal part");
      end if;                                 -- if procedure_unit statement
   elsif (BYPASS(TOKEN_FUNCTION)) then
      DECLARE_TYPE := FUNCTION_DECLARE;
      if (FUNCTION_UNIT) then
         return (TRUE);
      else
         SYNTAX_ERROR("Generic formal part");
      end if;                                 -- if function_unit statement
   elsif (BYPASS(TOKEN_PACKAGE)) then
      DECLARE_TYPE := PACKAGE_DECLARE;
      if (PACKAGE_DECLARATION) then
         return (TRUE);
      else
         SYNTAX_ERROR("Generic formal part");
      end if;                                 -- if package_declaration
   else
      return (FALSE);
   end if;
end GENERIC_FORMAL_PART;

--------------------------------------------------------------------------------

   -- PROCEDURE_UNIT -->  identifier [FORMAL_PART ?] is SUBPROGRAM_BODY
   --                -->  identifier [FORMAL_PART ?] ;
   --                -->  identifier [FORMAL_PART ?] renames NAME ;
function PROCEDURE_UNIT return boolean is
begin
```

```
   DECLARATION := TRUE;
   if (BYPASS(TOKEN_IDENTIFIER)) then
      SCOPE_LEVEL := SCOPE_LEVEL + 1;
      if (FORMAL_PART) then
         null;
      end if;                                  -- if formal part statement
      if (BYPASS(TOKEN_IS)) then
         if (SUBPROGRAM_BODY)  then
            SCOPE_LEVEL := SCOPE_LEVEL - 1;
            return (TRUE);
         else
            SYNTAX_ERROR("Procedure unit");
         end if;                               -- if subprogram body statement
      elsif (BYPASS(TOKEN_SEMICOLON)) then
         SCOPE_LEVEL := SCOPE_LEVEL - 1;
         return (TRUE);
      elsif (BYPASS(TOKEN_RENAMES)) then
         if (NAME) then
            if (BYPASS(TOKEN_SEMICOLON)) then
               SCOPE_LEVEL := SCOPE_LEVEL - 1;
               return (TRUE);
            else
               SYNTAX_ERROR("Procedure unit");
            end if;                            -- if bypass(token_semicolon)
         else
            SYNTAX_ERROR("Procedure unit");
         end if;                               -- if name statement
      end if;                                  -- if bypass(token_is)
   else
      return (FALSE);
   end if;                                     -- if bypass(token_identifier)
end PROCEDURE_UNIT;

--------------------------------------------------------------------------------

   -- SUBPROGRAM_BODY -->  new NAME [GENERIC_ACTUAL_PART ?] ;
   --                 -->  separate ;
   --                 -->  <> ;
   --                 -->  [DECLARATIVE_PART ?] begin SEQUENCE_OF_STATEMENTS
   --                     [exception [EXCEPTION_HANDLER]+ ?] end [DESIGNATOR ?] ;
   --                 -->  NAME ;
function SUBPROGRAM_BODY return boolean is
begin
   DECLARATION := TRUE;
   if (BYPASS(TOKEN_NEW))then
      if (NAME) then
         if (GENERIC_ACTUAL_PART) then
            null;
         end if;                               -- if generic actual part
         if (BYPASS(TOKEN_SEMICOLON)) then
            return (TRUE);
         else
            SYNTAX_ERROR("Subprogram body");
         end if;                               -- if bypass(token_semicolon)
      else
         SYNTAX_ERROR("Subprogram body");
      end if;                                  -- if name statement
   elsif (BYPASS(TOKEN_SEPARATE)) then
      if (BYPASS(TOKEN_SEMICOLON)) then
         return (TRUE);
      else
         SYNTAX_ERROR("Subprogram body");
      end if;                                  -- if bypass(token_semicolon)
   elsif (BYPASS(TOKEN_BRACKETS)) then
      if (BYPASS(TOKEN_SEMICOLON)) then
         return (TRUE);
      else
         SYNTAX_ERROR("Subprogram body");
      end if;                                  -- if bypass(token_semicolon)
```

```
elsif (DECLARATIVE_PART) then
   if (BYPASS(TOKEN_BEGIN)) then
      DECLARATION := FALSE;
      if (SEQUENCE_OF_STATEMENTS) then
         if (BYPASS(TOKEN_EXCEPTION)) then
            if (EXCEPTION_HANDLER) then
               while (EXCEPTION_HANDLER) loop
                  null;
               end loop;
            else
               SYNTAX_ERROR("Subprogram body");
            end if;                       -- if exception_handler statement
         end if;                          -- if bypass(token_exception)
         if (BYPASS(TOKEN_END)) then
            if (DESIGNATOR) then
               null;
            end if;                       -- if designator statement
            if (BYPASS(TOKEN_SEMICOLON)) then
               DECLARATION := TRUE;
               return (TRUE);
            else
               SYNTAX_ERROR("Subprogram body");
            end if;                       -- if bypass(token_semicolon)
         else
            SYNTAX_ERROR("Subprogram body");
         end if;                          -- if bypass(token_end)
      else
         SYNTAX_ERROR("Subprogram body");
      end if;                             -- if sequence of statements
   else
      SYNTAX_ERROR("Subprogram body");
   end if;                                -- if bypass(token_begin)
elsif (BYPASS(TOKEN_BEGIN)) then
   DECLARATION := FALSE;
   if (SEQUENCE_OF_STATEMENTS) then
      if (BYPASS(TOKEN_EXCEPTION)) then
         if (EXCEPTION_HANDLER) then
            while (EXCEPTION_HANDLER) loop
               null;
            end loop;
         else
            SYNTAX_ERROR("Subprogram body");
         end if;                          -- if exception_handler statement
      end if;                             -- if bypass(token_exception)
      if (BYPASS(TOKEN_END)) then
         if (DESIGNATOR) then
            null;
         end if;                          -- if designator statement
         if (BYPASS(TOKEN_SEMICOLON)) then
            DECLARATION := TRUE;
            return (TRUE);
         else
            SYNTAX_ERROR("Subprogram body");
         end if;                          -- if bypass(token_semicolon)
      else
         SYNTAX_ERROR("Subprogram body");
      end if;                             -- if bypass(token_end)
   else
      SYNTAX_ERROR("Subprogram body");
   end if;                                -- if sequence of statements
elsif (NAME) then
   if (BYPASS(TOKEN_SEMICOLON)) then
      return (TRUE);
   else
      SYNTAX_ERROR("Subprogram body");
   end if;                                -- if bypass(token_semicolon)
else
   return (FALSE);
end if;                                   -- if bypass(token_new)
```

```
end SUBPROGRAM_BODY;

--------------------------------------------------------------------------------

   -- FUNCTION_UNIT -->  DESIGNATOR  FUNCTION_UNIT_TAIL
function FUNCTION_UNIT return boolean is
begin
   DECLARATION := TRUE;
   if (DESIGNATOR) then
      SCOPE_LEVEL := SCOPE_LEVEL + 1;
      if (FUNCTION_UNIT_TAIL) then
         SCOPE_LEVEL := SCOPE_LEVEL - 1;
         return (TRUE);
      else
         SYNTAX_ERROR("Function unit");
      end if;
   else
      return (FALSE);
   end if;
end FUNCTION_UNIT;

--------------------------------------------------------------------------------

   -- FUNCTION_UNIT_TAIL -->  is new NAME [GENERIC_ACTUAL_PART ?] ;
   --                    -->  [FORMAL_PART ?] return NAME  FUNCTION_BODY
function FUNCTION_UNIT_TAIL return boolean is
begin
   if (BYPASS(TOKEN_IS)) then
      if (BYPASS(TOKEN_NEW)) then
         if (NAME) then
            if (GENERIC_ACTUAL_PART) then
               null;
            end if;                            -- if generic actual part
            if (BYPASS(TOKEN_SEMICOLON)) then
               return (TRUE);
            else
               SYNTAX_ERROR("Function unit tail");
            end if;                            -- if bypass(token_semicolon)
         else
            SYNTAX_ERROR("Function unit tail");
         end if;                               -- if name statement
      else
         SYNTAX_ERROR("Function unit tail");
      end if;                                  -- if bypass(token_new)
   elsif (FORMAL_PART) then
      if (BYPASS(TOKEN_RETURN)) then
         if (NAME) then                        -- check for type_mark
            if (FUNCTION_BODY) then
               return (TRUE);
            else
               SYNTAX_ERROR("Function unit tail");
            end if;                            -- if function body statement
         else
            SYNTAX_ERROR("Function unit tail");
         end if;                               -- if type mark statement
      else
         SYNTAX_ERROR("Function unit tail");
      end if;                                  -- if bypass(token_return)
   elsif (BYPASS(TOKEN_RETURN)) then
      if (NAME) then                           -- check for type_mark
         if (FUNCTION_BODY) then
            return (TRUE);
         else
            SYNTAX_ERROR("Function unit tail");
         end if;                               -- if function body statement
      else
         SYNTAX_ERROR("Function unit tail");
      end if;                                  -- if type mark statement
   else
```

```
      return (FALSE);
   end if;                                   -- if bypass(token_is)
end FUNCTION_UNIT_TAIL;

------------------------------------------------------------------------------

   -- FUNCTION_BODY -->  is [FUNCTION_BODY_TAIL ?]
   --            -->  ;
function FUNCTION_BODY return boolean is
begin
   if (BYPASS(TOKEN_IS)) then
      if (FUNCTION_BODY_TAIL) then
         null;
      end if;
      return (TRUE);
   elsif (BYPASS(TOKEN_SEMICOLON)) then
      return (TRUE);
   else
      return (FALSE);
   end if;
end FUNCTION_BODY;

------------------------------------------------------------------------------

   -- FUNCTION_BODY_TAIL -->  separate ;
   --                    -->  <> ;
   --                    -->  SUBPROGRAM_BODY
   --                    -->  NAME ;
function FUNCTION_BODY_TAIL return boolean is
begin
   if (BYPASS(TOKEN_SEPARATE)) then
      if (BYPASS(TOKEN_SEMICOLON)) then
         return (TRUE);
      else
         SYNTAX_ERROR("Function body tail");
      end if;                               -- if bypass(token_semicolon)
   elsif (BYPASS(TOKEN_BRACKETS)) then
      if (BYPASS(TOKEN_SEMICOLON)) then
         return (TRUE);
      else
         SYNTAX_ERROR("Function body tail");
      end if;                               -- if bypass(token_semicolon)
   elsif (SUBPROGRAM_BODY) then
      return (TRUE);
   elsif (NAME) then
      if (BYPASS(TOKEN_SEMICOLON)) then
         return (TRUE);
      else
         SYNTAX_ERROR("Function body tail");
      end if;                               -- if bypass(token_semicolon)
   else
      return (FALSE);
   end if;                                 -- if bypass(token_separate)
end FUNCTION_BODY_TAIL;

------------------------------------------------------------------------------

   -- TASK_DECLARATION -->  body TASK_BODY ;
   --                  -->  [type ?] identifier [is [ENTRY_DECLARATION]*
   --                          [REPRESENTATION_CLAUSE]* end [identifier ?] ?] ;
function TASK_DECLARATION return boolean is
begin
   DECLARATION := TRUE;
   if (BYPASS(TOKEN_TYPE)) then
      null;
   end if;                                 -- if bypass(token_type)
   if (BYPASS(TOKEN_BODY)) then
      if (TASK_BODY) then
         if (BYPASS(TOKEN_SEMICOLON)) then
```

```
            return (TRUE);
         else
            SYNTAX_ERROR("Task declaration");
         end if;
      else
         SYNTAX_ERROR("Task declaration");
      end if;                                 -- if task_body statement
   elsif (BYPASS(TOKEN_IDENTIFIER)) then
      SCOPE_LEVEL := SCOPE_LEVEL + 1;
      if (BYPASS(TOKEN_IS)) then
         while (ENTRY_DECLARATION) loop
            null;
         end loop;
         while (REPRESENTATION_CLAUSE) loop
            null;
         end loop;
         if (BYPASS(TOKEN_END)) then
            if (BYPASS(TOKEN_IDENTIFIER)) then
               null;
            end if;                           -- if bypass(token_identifier)
            if (BYPASS(TOKEN_SEMICOLON)) then
               SCOPE_LEVEL := SCOPE_LEVEL - 1;
               return (TRUE);
            else
               SYNTAX_ERROR("Task declaration");
            end if;                           -- if bypass(token_semicolon)
         else
            SYNTAX_ERROR("Task declaration");
         end if;                              -- if bypass(token_end)
      elsif (BYPASS(TOKEN_SEMICOLON)) then
         SCOPE_LEVEL := SCOPE_LEVEL - 1;
         return (TRUE);
      else
         SYNTAX_ERROR("Task declaration");
      end if;                                 -- if bypass(token_is)
   else
      return (FALSE);
   end if;                                    -- if bypass(token_body)
end TASK_DECLARATION;

--------------------------------------------------------------------------------

   -- TASK_BODY -->  identifier is TASK_BODY_TAIL
function TASK_BODY return boolean is
begin
   if (BYPASS(TOKEN_IDENTIFIER)) then
      SCOPE_LEVEL := SCOPE_LEVEL + 1;
      if (BYPASS(TOKEN_IS)) then
         if (TASK_BODY_TAIL) then
            SCOPE_LEVEL := SCOPE_LEVEL - 1;
            return (TRUE);
         else
            SYNTAX_ERROR("Task body");
         end if;                              -- if task_body_tail statement
      else
         SYNTAX_ERROR("Task body");
      end if;                                 -- if bypass(token_is)
   else
      return (FALSE);
   end if;                                    -- if bypass(token_identifier)
end TASK_BODY;

--------------------------------------------------------------------------------

   -- TASK_BODY_TAIL -->  separate
   --                -->  [DECLARATIVE_PART ?] begin SEQUENCE_OF_STATEMENTS
   --                     [exception [EXCEPTION_HANDLER]+ ?] end [identifier ?]
function TASK_BODY_TAIL return boolean is
begin
```

```
   DECLARATION := TRUE;
   if (BYPASS(TOKEN_SEPARATE)) then
      return (TRUE);
   elsif (DECLARATIVE_PART) then
      if (BYPASS(TOKEN_BEGIN)) then
         DECLARATION := FALSE;
         if (SEQUENCE_OF_STATEMENTS) then
            if (BYPASS(TOKEN_EXCEPTION)) then
               if (EXCEPTION_HANDLER) then
                  while (EXCEPTION_HANDLER) loop
                     null;
                  end loop;
               else
                  SYNTAX_ERROR("Task body tail");
               end if;                        -- if exception_handler statement
            end if;                           -- if bypass(token_exception)
            if (BYPASS(TOKEN_END)) then
               if (BYPASS(TOKEN_IDENTIFIER)) then
                  null;
               end if;                        -- if bypass(token_identifier)
               DECLARATION := TRUE;
               return (TRUE);
            else
               SYNTAX_ERROR("Task body tail");
            end if;                           -- if bypass(token_end)
         else
            SYNTAX_ERROR("Task body tail");
         end if;                              -- if sequence_of_statements
      else
         SYNTAX_ERROR("Task body tail");
      end if;                                 -- if bypass(token_begin)
   elsif (BYPASS(TOKEN_BEGIN)) then
      DECLARATION := FALSE;
      if (SEQUENCE_OF_STATEMENTS) then
         if (BYPASS(TOKEN_EXCEPTION)) then
            if (EXCEPTION_HANDLER) then
               while (EXCEPTION_HANDLER) loop
                  null;
               end loop;
            else
               SYNTAX_ERROR("Task body tail");
            end if;                           -- if exception_handler statement
         end if;                              -- if bypass(token_exception)
         if (BYPASS(TOKEN_END)) then
            if (BYPASS(TOKEN_IDENTIFIER)) then
               null;
            end if;                           -- if bypass(token_identifier)
            DECLARATION := TRUE;
            return (TRUE);
         else
            SYNTAX_ERROR("Task body tail");
         end if;                              -- if bypass(token_end)
      else
         SYNTAX_ERROR("Task body tail");
      end if;                                 -- if sequence_of_statements
   else
      return (FALSE);
   end if;                                    -- if bypass(token_separate)
end TASK_BODY_TAIL;

------------------------------------------------------------------------------

   -- PACKAGE_DECLARATION --> body PACKAGE_BODY
   --                     --> identifier PACKAGE_UNIT
function PACKAGE_DECLARATION return boolean is
begin
   DECLARATION := TRUE;
   if (BYPASS(TOKEN_BODY)) then
      if (PACKAGE_BODY) then
```

```
         return (TRUE);
      else
         SYNTAX_ERROR("Package declaration");
      end if;                              -- if package unit statement
   elsif (BYPASS(TOKEN_IDENTIFIER)) then
      SCOPE_LEVEL := SCOPE_LEVEL + 1;
      if (PACKAGE_UNIT) then
         SCOPE_LEVEL := SCOPE_LEVEL - 1;
         return (TRUE);
      else
         SYNTAX_ERROR("Package declaration");
      end if;                              -- if package_unit_tail statement
   else
      return (FALSE);
   end if;                                 -- if bypass(token_package)
end PACKAGE_DECLARATION;

-------------------------------------------------------------------------------

   -- PACKAGE_BODY -->  identifier is PACKAGE_BODY_TAIL
function PACKAGE_BODY return boolean is
begin
   if (BYPASS(TOKEN_IDENTIFIER)) then
      SCOPE_LEVEL := SCOPE_LEVEL + 1;
      if (BYPASS(TOKEN_IS)) then
         if (PACKAGE_BODY_TAIL) then
            SCOPE_LEVEL := SCOPE_LEVEL - 1;
            return (TRUE);
         else
            SYNTAX_ERROR("Package body");
         end if;                           -- if package_body_tail statement
      else
         SYNTAX_ERROR("Package body");
      end if;                              -- if bypass(token_is)
   else
      return (FALSE);
   end if;                                 -- if bypass(token_identifier)
end PACKAGE_BODY;

-------------------------------------------------------------------------------

   -- PACKAGE_BODY_TAIL -->  separate ;
   --                   -->  [DECLARATIVE_PART ?] [begin SEQUENCE_OF_STATEMENTS
   --                          [exception [EXCEPTION_HANDLER]+ ?] ?]
   --                          end [identifier ?] ;
function PACKAGE_BODY_TAIL return boolean is
begin
   DECLARATION := TRUE;
   if (BYPASS(TOKEN_SEPARATE)) then
      if (BYPASS(TOKEN_SEMICOLON)) then
         return (TRUE);
      else
         SYNTAX_ERROR("Package body tail");
      end if;                              -- if bypass(token_semicolon)
   elsif (DECLARATIVE_PART) then
      DECLARATION := FALSE;
      if (BYPASS(TOKEN_BEGIN)) then
         if (SEQUENCE_OF_STATEMENTS) then
            if (BYPASS(TOKEN_EXCEPTION)) then
               if (EXCEPTION_HANDLER) then
                  while (EXCEPTION_HANDLER) loop
                     null;
                  end loop;
               else
                  SYNTAX_ERROR("Package body tail");
               end if;                     -- if exception_handler statement
            end if;                        -- if bypass(token_exception)
            if (BYPASS(TOKEN_END)) then
               if (BYPASS(TOKEN_IDENTIFIER)) then
```

```
                null;
             end if;                        -- if bypass(token_identifier)
             if (BYPASS(TOKEN_SEMICOLON)) then
                DECLARATION := TRUE;
                return (TRUE);
             else
                SYNTAX_ERROR("Package body tail");
             end if;                        -- if bypass(token_semicolon)
          else
             SYNTAX_ERROR("Package body tail");
          end if;                           -- if bypass(token_end)
       else
          SYNTAX_ERROR("Package body tail");
       end if;                              -- if sequence_of_statements
    elsif (BYPASS(TOKEN_END)) then
       if (BYPASS(TOKEN_IDENTIFIER)) then
          null;
       end if;                              -- if bypass(token_identifier)
       if (BYPASS(TOKEN_SEMICOLON)) then
          DECLARATION := TRUE;
          return (TRUE);
       else
           SYNTAX_ERROR("Package body tail");
       end if;                              -- if bypass(token_semicolon)
    else
       SYNTAX_ERROR("Package body tail");
    end if;                                 -- if bypass(token_begin)
 elsif (BYPASS(TOKEN_BEGIN)) then
    DECLARATION := FALSE;
    if (SEQUENCE_OF_STATEMENTS) then
       if (BYPASS(TOKEN_EXCEPTION)) then
          if (EXCEPTION_HANDLER) then
             while (EXCEPTION_HANDLER) loop
                null;
             end loop;
          else
             SYNTAX_ERROR("Package body tail");
          end if;                           -- if exception_handler statement
       end if;                              -- if bypass(token_exception)
       if (BYPASS(TOKEN_END)) then
          if (BYPASS(TOKEN_IDENTIFIER)) then
             null;
          end if;                           -- if bypass(token_identifier)
          if (BYPASS(TOKEN_SEMICOLON)) then
             DECLARATION := TRUE;
             return (TRUE);
          else
             SYNTAX_ERROR("Package body tail");
          end if;                           -- if bypass(token_semicolon)
       else
          SYNTAX_ERROR("Package body tail");
       end if;                              -- if bypass(token_end)
    else
       SYNTAX_ERROR("Package body tail");
    end if;                                 -- if sequence_of_statements
 elsif (BYPASS(TOKEN_END)) then
    if (BYPASS(TOKEN_IDENTIFIER)) then
       null;
    end if;                                 -- if bypass(token_identifier)
    if (BYPASS(TOKEN_SEMICOLON)) then
       return (TRUE);
    else
       SYNTAX_ERROR("Package body tail");
    end if;                                 -- if bypass(token_semicolon)
 else
    return (FALSE);
 end if;                                    -- if bypass(token_separate)
end PACKAGE_BODY_TAIL;
```

```
-----------------------------------------------------------------------------

   -- PACKAGE_UNIT -->  is PACKAGE_TAIL_END
   --              -->  renames NAME ;
function PACKAGE_UNIT return boolean is
begin
   if (BYPASS(TOKEN_IS)) then
      if (PACKAGE_TAIL_END) then
         return (TRUE);
      else
         SYNTAX_ERROR("Package unit");
      end if;
   elsif (BYPASS(TOKEN_RENAMES)) then
      if (NAME) then
         if (BYPASS(TOKEN_SEMICOLON)) then
            return (TRUE);
         else
            SYNTAX_ERROR("Package unit");
         end if;                          -- if bypass(token_semicolon)
      else
         SYNTAX_ERROR("Package unit");
      end if;                             -- if name statement
   else
      return (FALSE);
   end if;                                -- if bypass(token_is)
end PACKAGE_UNIT;

-----------------------------------------------------------------------------

   -- PACKAGE_TAIL_END -->  new NAME [GENERIC_ACTUAL_PART ?] ;
   --                  -->  [BASIC_DECLARATIVE_ITEM]* [private
   --                          [BASIC_DECLARATIVE_ITEM]* ?] end [identifier ?] ;
function PACKAGE_TAIL_END return boolean is
begin
   if (BYPASS(TOKEN_NEW)) then
      if (NAME) then
         if (GENERIC_ACTUAL_PART) then
            null;
         end if;                          -- if generic_actual_part statement
         if (BYPASS(TOKEN_SEMICOLON)) then
            return (TRUE);
         else
            SYNTAX_ERROR("Package tail end");
         end if;                          -- if bypass(token_semicolon)
      else
         SYNTAX_ERROR("Package tail end");
      end if;                             -- if name statement
   elsif (BASIC_DECLARATIVE_ITEM) then
      while (BASIC_DECLARATIVE_ITEM) loop
         null;
      end loop;
      if (BYPASS(TOKEN_PRIVATE)) then
         while (BASIC_DECLARATIVE_ITEM) loop
            null;
         end loop;
      end if;                             -- if bypass(token_private)
      if (BYPASS(TOKEN_END)) then
         if (BYPASS(TOKEN_IDENTIFIER)) then
            null;
         end if;
         if (BYPASS(TOKEN_SEMICOLON)) then
            return (TRUE);
         else
            SYNTAX_ERROR("Package tail end");
         end if;                          -- if bypass(token_semicolon)
      else
         SYNTAX_ERROR("Package tail end");
      end if;                             -- if bypass(token_end)
   elsif (BYPASS(TOKEN_PRIVATE)) then
```

```
      while (BASIC_DECLARATIVE_ITEM) loop
         null;
      end loop;
      if (BYPASS(TOKEN_END)) then
         if (BYPASS(TOKEN_IDENTIFIER)) then
            null;
         end if;
         if (BYPASS(TOKEN_SEMICOLON)) then
            return (TRUE);
         else
            SYNTAX_ERROR("Package tail end");
         end if;                          -- if bypass(token_semicolon)
      else
         SYNTAX_ERROR("Package tail end");
      end if;                             -- if bypass(token_end)
   elsif (BYPASS(TOKEN_END)) then
      if (BYPASS(TOKEN_IDENTIFIER)) then
         null;
      end if;
      if (BYPASS(TOKEN_SEMICOLON)) then
         return (TRUE);
      else
         SYNTAX_ERROR("Package tail end");
      end if;                             -- if bypass(token_semicolon)
   else
      return (FALSE);
   end if;                                -- if bypass(token_new)
end PACKAGE_TAIL_END;

--------------------------------------------------------------------------------

   -- BASIC_DECLARATIVE_ITEM -->  BASIC_DECLARATIVE
   --                        -->  REPRESENTATION_CLAUSE
   --                        -->  use WITH_OR_USE_CLAUSE
function BASIC_DECLARATIVE_ITEM return boolean is
begin
   if (BASIC_DECLARATION) then
      return (TRUE);
   elsif (REPRESENTATION_CLAUSE) then
      return (TRUE);
   elsif (BYPASS(TOKEN_USE)) then
      if (WITH_OR_USE_CLAUSE) then
         return (TRUE);
      else
         SYNTAX_ERROR("Basic declarative item");
      end if;
   else
      return (FALSE);
   end if;
end BASIC_DECLARATIVE_ITEM;

--------------------------------------------------------------------------------

   -- DECLARATIVE_PART -->  [BASIC_DECLARATIVE_ITEM]* [LATER_DECLARATIVE_ITEM]*
function DECLARATIVE_PART return boolean is
begin
   while (BASIC_DECLARATIVE_ITEM) loop
      null;
   end loop;
   while (LATER_DECLARATIVE_ITEM) loop
      null;
   end loop;
   return (TRUE);
end DECLARATIVE_PART;

--------------------------------------------------------------------------------

   -- BASIC_DECLARATION -->  type TYPE_DECLARATION
   --                   -->  subtype SUBTYPE_DECLARATION
```

```
   --                       -->  procedure PROCEDURE_UNIT
   --                       -->  function FUNCTION_UNIT
   --                       -->  package PACKAGE_DECLARATION
   --                       -->  generic GENERIC_DECLARATION
   --                       -->  IDENTIFIER_DECLARATION
   --                       -->  task TASK_DECLARATION
function BASIC_DECLARATION return boolean is
begin
   if (BYPASS(TOKEN_TYPE)) then
      if (TYPE_DECLARATION) then
         return (TRUE);
      else
         SYNTAX_ERROR("Basic declaration");
      end if;
   elsif (BYPASS(TOKEN_SUBTYPE)) then
      if (SUBTYPE_DECLARATION) then
         return (TRUE);
      else
         SYNTAX_ERROR("Basic declaration");
      end if;
   elsif (BYPASS(TOKEN_PROCEDURE)) then
      DECLARE_TYPE := PROCEDURE_DECLARE;
      if (PROCEDURE_UNIT) then
         return (TRUE);
      else
         SYNTAX_ERROR("Basic declaration");
      end if;                               -- if procedure_unit statement
   elsif (BYPASS(TOKEN_FUNCTION)) then
      DECLARE_TYPE := FUNCTION_DECLARE;
      if (FUNCTION_UNIT) then
         return (TRUE);
      else
         SYNTAX_ERROR("Basic declaration");
      end if;                               -- if function_unit statement
   elsif (BYPASS(TOKEN_PACKAGE)) then
      DECLARE_TYPE := PACKAGE_DECLARE;
      if (PACKAGE_DECLARATION) then
         return (TRUE);
      else
         SYNTAX_ERROR("Basic declaration");
      end if;                               -- if package_declaration
   elsif (BYPASS(TOKEN_GENERIC)) then
      if (GENERIC_DECLARATION) then
         return (TRUE);
      else
         SYNTAX_ERROR("Basic declaration");
      end if;                               -- if generic_declaration
   elsif (IDENTIFIER_DECLARATION) then
      return (TRUE);
   elsif (BYPASS(TOKEN_TASK)) then
      DECLARE_TYPE := TASK_DECLARE;
      if (TASK_DECLARATION) then
         return (TRUE);
      else
         SYNTAX_ERROR("Basic declaration");
      end if;
   else
      return (FALSE);
   end if;
end BASIC_DECLARATION;

--------------------------------------------------------------------------------

   -- LATER_DECLARATIVE_ITEM -->  PROPER_BODY
   --                        -->  generic GENERIC_DECLARATION
   --                        -->  use WITH_OR_USE_CLAUSE
function LATER_DECLARATIVE_ITEM return boolean is
begin
   if (PROPER_BODY) then                 -- check for body_declaration
```

```
      return (TRUE);
   elsif (BYPASS(TOKEN_GENERIC)) then
      if (GENERIC_DECLARATION) then
         return (TRUE);
      else
         SYNTAX_ERROR("Later declarative item");
      end if;                              -- if generic_declaration
   elsif (BYPASS(TOKEN_USE)) then
      if (WITH_OR_USE_CLAUSE) then
         return (TRUE);
      else
         SYNTAX_ERROR("Later declarative item");
      end if;                              -- if with_or_use_clause
   else
      return (FALSE);
   end if;
end LATER_DECLARATIVE_ITEM;

--------------------------------------------------------------------------------

   -- PROPER_BODY -->  procedure PROCEDURE_UNIT
   --             -->  function FUNCTION_UNIT
   --             -->  package PACKAGE_DECLARATION
   --             -->  task TASK_DECLARATION
function PROPER_BODY return boolean is
begin
   if (BYPASS(TOKEN_PROCEDURE)) then
      DECLARE_TYPE := PROCEDURE_DECLARE;
      if (PROCEDURE_UNIT) then
         return (TRUE);
      else
         SYNTAX_ERROR("Proper body");
      end if;                              -- if procedure_unit statement
   elsif (BYPASS(TOKEN_FUNCTION)) then
      DECLARE_TYPE := FUNCTION_DECLARE;
      if (FUNCTION_UNIT) then
         return (TRUE);
      else
         SYNTAX_ERROR("Proper body");
      end if;                              -- if function_unit statement
   elsif (BYPASS(TOKEN_PACKAGE)) then
      DECLARE_TYPE := PACKAGE_DECLARE;
      if (PACKAGE_DECLARATION) then
         return (TRUE);
      else
         SYNTAX_ERROR("Proper body");
      end if;                              -- if package_declaration
   elsif (BYPASS(TOKEN_TASK)) then
      DECLARE_TYPE := TASK_DECLARE;
      if (TASK_DECLARATION) then
         return (TRUE);
      else
         SYNTAX_ERROR("Proper body");
      end if;
   else
      return (FALSE);
   end if;                                -- if bypass(token_procedure)
end PROPER_BODY;

--------------------------------------------------------------------------------

   -- SEQUENCE_OF_STATEMENTS -->  [STATEMENT]+
function SEQUENCE_OF_STATEMENTS return boolean is
begin
   if (STATEMENT) then
      while (STATEMENT) loop
         null;
      end loop;
      return (TRUE);
```

```
   else
      return (FALSE);
   end if;
end SEQUENCE_OF_STATEMENTS;

---------------------------------------------------------------------------

   -- STATEMENT -->  [LABEL ?] SIMPLE_STATEMENT
   --           -->  [LABEL ?] COMPOUND_STATEMENT
function STATEMENT return boolean is
begin
   if (LABEL) then
      null;
   end if;
   if (SIMPLE_STATEMENT) then
      return (TRUE);
   elsif (COMPOUND_STATEMENT) then
      return (TRUE);
   else
      return (FALSE);
   end if;
end STATEMENT;

---------------------------------------------------------------------------

   -- COMPOUND_STATEMENT -->  if IF_STATEMENT
   --                    -->  case CASE_STATEMENT
   --                    -->  LOOP_STATEMENT
   --                    -->  BLOCK_STATEMENT
   --                    -->  accept ACCEPT_STATEMENT
   --                    -->  select SELECT_STATEMENT
function COMPOUND_STATEMENT return boolean is
begin
   if (BYPASS(TOKEN_IF)) then
      NESTING_METRIC(IF_CONSTRUCT);
      if (IF_STATEMENT) then
         return (TRUE);
      else
         SYNTAX_ERROR("Compound statement");
      end if;                              -- if if_statement
   elsif (BYPASS(TOKEN_CASE)) then
      NESTING_METRIC(CASE_CONSTRUCT);
      if (CASE_STATEMENT) then
         return (TRUE);
      else
         SYNTAX_ERROR("Compound statement");
      end if;                              -- if case_statement
   elsif (LOOP_STATEMENT) then
      return (TRUE);
   elsif (BLOCK_STATEMENT) then
      return (TRUE);
   elsif (BYPASS(TOKEN_ACCEPT)) then
      if (ACCEPT_STATEMENT) then
         return (TRUE);
      else
         SYNTAX_ERROR("Compound statement");
      end if;
   elsif (BYPASS(TOKEN_SELECT)) then
      if (SELECT_STATEMENT) then
         return (TRUE);
      else
         SYNTAX_ERROR("Compound statement");
      end if;
   else
      return (FALSE);
   end if;
end COMPOUND_STATEMENT;

---------------------------------------------------------------------------
```

```
   -- BLOCK_STATEMENT -->  [identifier : ?] [declare DECLARATIVE_PART ?]
   --                        begin SEQUENCE_OF_STATEMENTS [exception
   --                        [EXCEPTION_HANDLER]+ ?] ?] end [identifier ?] ;
function BLOCK_STATEMENT return boolean is
   DECLARE_STATUS : boolean;
begin
   if (DECLARATION) then
      DECLARE_STATUS := TRUE;
   else
      DECLARATION := TRUE;
      DECLARE_STATUS := FALSE;
   end if;
   DECLARE_TYPE := BLOCK_DECLARE;
   if (BYPASS(TOKEN_IDENTIFIER)) then
      SCOPE_LEVEL := SCOPE_LEVEL + 1;
      if (BYPASS(TOKEN_COLON)) then
         SCOPE_LEVEL := SCOPE_LEVEL - 1;
      else
         SYNTAX_ERROR("Block statement");
      end if;                              -- if bypass(token_colon)
   else
      DECLARE_TYPE := VARIABLE_DECLARE;
   end if;                                 -- if bypass(token_identifier)
   if (BYPASS(TOKEN_DECLARE)) then
      SCOPE_LEVEL := SCOPE_LEVEL + 1;
      if (DECLARATIVE_PART) then
         null;
      else
         SYNTAX_ERROR("Block statement");
      end if;                              -- if declarative_part statement
   end if;                                 -- if bypass(token_declare)
   if (BYPASS(TOKEN_BEGIN)) then
      DECLARATION := FALSE;
      if (SEQUENCE_OF_STATEMENTS) then
         if (BYPASS(TOKEN_EXCEPTION)) then
            if (EXCEPTION_HANDLER) then
               while (EXCEPTION_HANDLER) loop
                  null;
               end loop;
            else
               SYNTAX_ERROR("Block statement");
            end if;                        -- if exception_handler statement
         end if;                           -- if bypass(token_exception)
         if (BYPASS(TOKEN_END)) then
            if (BYPASS(TOKEN_IDENTIFIER)) then
               null;
            end if;                        -- if bypass(token_identifier)
            if (BYPASS(TOKEN_SEMICOLON)) then
               SCOPE_LEVEL := SCOPE_LEVEL - 1;
               DECLARATION := TRUE;
               return (TRUE);
            else
               SYNTAX_ERROR("Block statement");
            end if;                        -- if bypass(token_semicolon)
         else
            SYNTAX_ERROR("Block statement");
         end if;                           -- if bypass(token_end)
      else
         SYNTAX_ERROR("Block statement");
      end if;                              -- if sequence_of_statements
   else
      if not (DECLARE_STATUS) then
         DECLARATION := FALSE;
      end if;
      return (FALSE);
   end if;                                 -- if bypass(token_begin)
end BLOCK_STATEMENT;
```

```
-------------------------------------------------------------------------

   -- IF_STATEMENT -->  EXPRESSION then SEQUENCE_OF_STATEMENTS
   --                    [elsif EXPRESSION then SEQUENCE_OF_STATEMENTS]*
   --                    [else SEQUENCE_OF_STATEMENTS ?] end if ;
function IF_STATEMENT return boolean is
begin
   if (EXPRESSION) then
      if (BYPASS(TOKEN_THEN)) then
         if (SEQUENCE_OF_STATEMENTS) then
            while (BYPASS(TOKEN_ELSIF)) loop
               if (EXPRESSION) then
                  if (BYPASS(TOKEN_THEN)) then
                     if not (SEQUENCE_OF_STATEMENTS) then
                        SYNTAX_ERROR("If statement");
                     end if;                  -- if not sequence_of_statements
                  else
                     SYNTAX_ERROR("If statement");
                  end if;                     -- if bypass(token_then)
               else
                  SYNTAX_ERROR("If statement");
               end if;                        -- if expression statement
            end loop;
            if (BYPASS(TOKEN_ELSE)) then
               if (SEQUENCE_OF_STATEMENTS) then
                  null;
               else
                  SYNTAX_ERROR("If statement");
               end if;                        -- if sequence_of_statements
            end if;                           -- if bypass(token_else)
            if (BYPASS(TOKEN_END)) then
               if (BYPASS(TOKEN_IF)) then
                  if (BYPASS(TOKEN_SEMICOLON)) then
                     NESTING_METRIC(IF_END);
                     return (TRUE);
                  else
                     SYNTAX_ERROR("If statement");
                  end if;                     -- if bypass(token_semicolon)
               else
                  SYNTAX_ERROR("If statement");
               end if;                        -- if bypass(token_if)
            else
               SYNTAX_ERROR("If statement");
            end if;                           -- if bypass(token_end)
         else
            SYNTAX_ERROR("If statement");
         end if;                              -- if sequence_of_statements
      else
         SYNTAX_ERROR("If statement");
      end if;                                 -- if bypass(token_then)
   else
      return (FALSE);
   end if;                                    -- if expression statement
end IF_STATEMENT;

-------------------------------------------------------------------------

  -- CASE_STATEMENT -->  EXPRESSION is [CASE_STATEMENT_ALTERNATIVE]+ end case ;
function CASE_STATEMENT return boolean is
begin
   if (EXPRESSION) then
      if (BYPASS(TOKEN_IS)) then
         if (CASE_STATEMENT_ALTERNATIVE) then
            while (CASE_STATEMENT_ALTERNATIVE) loop
               null;
            end loop;
            if (BYPASS(TOKEN_END)) then
               if (BYPASS(TOKEN_CASE)) then
                  if (BYPASS(TOKEN_SEMICOLON)) then
```

```
                  NESTING_METRIC(CASE_END);
                  return (TRUE);
               else
                  SYNTAX_ERROR("Case statement");
               end if;                        -- if bypass(token_semicolon)
            else
               SYNTAX_ERROR("Case statement");
            end if;                           -- if bypass(token_case)
         else
            SYNTAX_ERROR("Case statement");
         end if;                              -- if bypass(token_end)
      else
         SYNTAX_ERROR("Case statement");
      end if;                                 -- if case_statement_alternative
   else
      SYNTAX_ERROR("Case statement");
   end if;                                    -- if bypass(token_is)
else
   return (FALSE);
end if;                                       -- if expression statement
end CASE_STATEMENT;

------------------------------------------------------------------------------

   -- CASE_STATEMENT_ALTERNATIVE -->  when CHOICE [  CHOICE]* =>
   --                                        SEQUENCE_OF_STATEMENTS
function CASE_STATEMENT_ALTERNATIVE return boolean is
begin
   if (BYPASS(TOKEN_WHEN)) then
      if (CHOICE) then
         while (BYPASS(TOKEN_BAR)) loop
            if not (CHOICE) then
               SYNTAX_ERROR("Case statement alternative");
            end if;                           -- if not choice statement
         end loop;
         if (BYPASS(TOKEN_ARROW)) then
            if (SEQUENCE_OF_STATEMENTS) then
               return (TRUE);
            else
               SYNTAX_ERROR("Case statement alternative");
            end if;                           -- if sequence_of_statements
         else
            SYNTAX_ERROR("Case statement alternative");
         end if;                              -- if bypass(token_arrow)
      else
         SYNTAX_ERROR("Case statement alternative");
      end if;                                 -- if choice statement
   else
      return (FALSE);
   end if;                                    -- if bypass(token_when)
end CASE_STATEMENT_ALTERNATIVE;

------------------------------------------------------------------------------

   -- LOOP_STATEMENT -->  [identifier : ?] [ITERATION_SCHEME ?] loop
   --                          SEQUENCE_OF_STATEMENTS end loop [identifier ?] ;
function LOOP_STATEMENT return boolean is
begin
   if (BYPASS(TOKEN_IDENTIFIER)) then
      if (BYPASS(TOKEN_COLON)) then
         null;
      else
         SYNTAX_ERROR("Loop statement");
      end if;                                 -- if bypass(token_colon)
   end if;                                    -- if bypass(token_identifier)
   if (ITERATION_SCHEME) then
      NO_ITERATION := FALSE;
   end if;                                    -- if iteration_scheme statement
   if (BYPASS(TOKEN_LOOP)) then
```

```
         if (NO_ITERATION) then
            NESTING_METRIC(LOOP_CONSTRUCT);
         else
            NO_ITERATION := TRUE;
         end if;
         if (SEQUENCE_OF_STATEMENTS) then
            if (BYPASS(TOKEN_END)) then
               if (BYPASS(TOKEN_LOOP)) then
                  if (BYPASS(TOKEN_IDENTIFIER)) then
                     null;
                  end if;                      -- if bypass(token_identifier)
                  if (BYPASS(TOKEN_SEMICOLON)) then
                     NESTING_METRIC(LOOP_END);
                     return (TRUE);
                  else
                     SYNTAX_ERROR("Loop statement");
                  end if;                      -- if bypass(token_semicolon)
               else
                  SYNTAX_ERROR("Loop statement");
               end if;                         -- if bypass(token_loop)
            else
               SYNTAX_ERROR("Loop statement");
            end if;                            -- if bypass(token_end)
         else
            SYNTAX_ERROR("Loop statement");
         end if;                               -- if sequence_of_statements
      else
         return (FALSE);
      end if;                                  -- if bypass(token_loop)
   end LOOP_STATEMENT;

   ---------------------------------------------------------------------------

      -- EXCEPTION_HANDLER -->  when EXCEPTION_CHOICE [  EXCEPTION_CHOICE]* =>
      --                          SEQUENCE_OF_STATEMENTS
   function EXCEPTION_HANDLER return boolean is
   begin
      if (BYPASS(TOKEN_WHEN)) then
         if (EXCEPTION_CHOICE) then
            while (BYPASS(TOKEN_BAR)) loop
               if not (EXCEPTION_CHOICE) then
                  SYNTAX_ERROR("Exception handler");
               end if;                         -- if not exception_choice
            end loop;
            if (BYPASS(TOKEN_ARROW)) then
               if (SEQUENCE_OF_STATEMENTS) then
                  return (TRUE);
               else
                  SYNTAX_ERROR("Exception handler");
               end if;                         -- if sequence_of_statements
            else
               SYNTAX_ERROR("Exception handler");
            end if;                            -- if bypass(token_arrow)
         else
            SYNTAX_ERROR("Exception handler");
         end if;                               -- if exception_choice statement
      else
         return (FALSE);
      end if;                                  -- if bypass(token-when)
   end EXCEPTION_HANDLER;

   ---------------------------------------------------------------------------

      -- ACCEPT_STATEMENT -->  identifier [(EXPRESSION) ?] [FORMAL_PART ?]
      --                        [do SEQUENCE_OF_STATEMENTS end [identifier ?] ?] ;
   function ACCEPT_STATEMENT return boolean is
   begin
      if (BYPASS(TOKEN_IDENTIFIER)) then
         if (BYPASS(TOKEN_LEFT_PAREN)) then
```

```
         if (EXPRESSION) then
            if (BYPASS(TOKEN_RIGHT_PAREN)) then
               null;
            else
               SYNTAX_ERROR("Accept statement");
            end if;                              -- if bypass(token_right_paren)
         else
            SYNTAX_ERROR("Accept statement");
         end if;                              -- if expression statement
      end if;                              -- if bypass(token_left_paren)
      if (FORMAL_PART) then
         null;
      end if;                              -- if formal_part statement
      if (BYPASS(TOKEN_DO)) then
         if (SEQUENCE_OF_STATEMENTS) then
            if (BYPASS(TOKEN_END)) then
               if (BYPASS(TOKEN_IDENTIFIER)) then
                  null;
               end if;                           -- if bypass(token_identifier)
            else
               SYNTAX_ERROR("Accept statement");
            end if;                    -- if bypass(token_end)
         else
            SYNTAX_ERROR("Accept statement");
         end if;                              -- if sequence_of_statements
      end if;                              -- if bypass(token_do)
      if (BYPASS(TOKEN_SEMICOLON)) then
         return (TRUE);
      else
         SYNTAX_ERROR("Accept statement");
      end if;                              -- if bypass(token_semicolon)
   else
      return (FALSE);
   end if;                              -- if bypass(token_identifier)
end ACCEPT_STATEMENT;

--------------------------------------------------------------------------------

   -- SELECT_STATEMENT -->  SELECT_STATEMENT_TAIL  SELECT_ENTRY_CALL end select ;
function SELECT_STATEMENT return boolean is
begin
   if (SELECT_STATEMENT_TAIL) then
      if (SELECT_ENTRY_CALL) then
         if (BYPASS(TOKEN_END)) then
            if (BYPASS(TOKEN_SELECT)) then
               if (BYPASS(TOKEN_SEMICOLON)) then
                  return (TRUE);
               else
                  SYNTAX_ERROR("Select statement");
               end if;                           -- if bypass(token_semicolon)
            else
               SYNTAX_ERROR("Select statement");
            end if;                              -- if bypass(token_select)
         else
            SYNTAX_ERROR("Select statement");
         end if;                              -- if bypass(token_end)
      else
         SYNTAX_ERROR("Select statement");
      end if;                              -- if select_entry_call statement
   else
      return (FALSE);
   end if;                              -- if select_statement_tail
end SELECT_STATEMENT;

--------------------------------------------------------------------------------

   -- SELECT_STATEMENT_TAIL -->  SELECT_ALTERNATIVE [or SELECT_ALTERNATIVE]*
   --                       -->  NAME ; [SEQUENCE_OF_STATEMENTS ?]
function SELECT_STATEMENT_TAIL return boolean is
```

```
begin
   if (SELECT_ALTERNATIVE) then
      while (BYPASS(TOKEN_OR)) loop
         if not (SELECT_ALTERNATIVE) then
            SYNTAX_ERROR("Select statement tail");
         end if;
      end loop;
      return (TRUE);
   elsif (NAME) then                        -- check for entry call statement
      if (BYPASS(TOKEN_SEMICOLON)) then
         if (SEQUENCE_OF_STATEMENTS) then
            null;
         end if;                              -- if sequence_of_statements
         return (TRUE);
      else
         SYNTAX_ERROR("Select statement tail");
      end if;                                -- if bypass(token_semicolon)
   else
      return (FALSE);
   end if;                                  -- if select_alternative statement
end SELECT_STATEMENT_TAIL;

-------------------------------------------------------------------------------

   -- SELECT_ALTERNATIVE -->  [when EXPRESSION => ?] accept ACCEPT_STATEMENT
   --                              [SEQUENCE_OF_STATEMENTS ?]
   --                     -->  [when EXPRESSION => ?] delay DELAY_STATEMENT
   --                              [SEQUENCE_OF_STATEMENTS ?]
   --                     -->  [when EXPRESSION => ?] terminate ;
function SELECT_ALTERNATIVE return boolean is
begin
   if (BYPASS(TOKEN_WHEN)) then
      if (EXPRESSION) then
         if (BYPASS(TOKEN_ARROW)) then
            null;
         else
            SYNTAX_ERROR("Select alternative");
         end if;                              -- if bypass(token_arrow)
      else
         SYNTAX_ERROR("Select alternative");
      end if;                                -- if expression statement
   end if;                                  -- if bypass(token_when)
   if (BYPASS(TOKEN_ACCEPT)) then
      if (ACCEPT_STATEMENT) then
         if (SEQUENCE_OF_STATEMENTS) then
            null;
         end if;                              -- if sequence_of_statements
         return (TRUE);
      else
         SYNTAX_ERROR("Select alternative");
      end if;                                -- if accept_statement
   elsif (BYPASS(TOKEN_DELAY)) then
      if (DELAY_STATEMENT) then
         if (SEQUENCE_OF_STATEMENTS) then
            null;
         end if;                              -- if sequence_of_statements
         return (TRUE);
      else
         SYNTAX_ERROR("Select alternative");
      end if;                                -- if delay_statement
   elsif (BYPASS(TOKEN_TERMINATE)) then
      if (BYPASS(TOKEN_SEMICOLON)) then
         return (TRUE);
      else
         SYNTAX_ERROR("Select alternative");
      end if;                                -- if bypass(token_semicolon)
   else
      return (FALSE);
   end if;                                  -- if bypass(token_accept)
```

```
end SELECT_ALTERNATIVE;

---------------------------------------------------------------------------------

   -- SELECT_ENTRY_CALL --> else SEQUENCE_OF_STATEMENTS
   --                   --> or delay DELAY_STATEMENT [SEQUENCE_OF_STATEMENTS ?]
function SELECT_ENTRY_CALL return boolean is
begin
   if (BYPASS(TOKEN_ELSE)) then
      if (SEQUENCE_OF_STATEMENTS) then
         return (TRUE);
      else
         SYNTAX_ERROR("Select entry call");
      end if;                          -- if sequence_of_statements
   elsif (BYPASS(TOKEN_OR)) then
      if (BYPASS(TOKEN_DELAY)) then
         if (DELAY_STATEMENT) then
            if (SEQUENCE_OF_STATEMENTS) then
               null;
            end if;                    -- if sequence_of_statements
            return (TRUE);
         else
            SYNTAX_ERROR("Select entry call");
         end if;                       -- if delay_statement
      else
         SYNTAX_ERROR("Select entry call");
      end if;                          -- if bypass(token_delay)
   else
      return (FALSE);
   end if;                             -- if bypass(token_else)
end SELECT_ENTRY_CALL;

end PARSER_1;
```

APPENDIX E

'ADAMEASURE' PROGRAM LISTING - PART 3

```
--*************************************************************--
--                                                             --
--  TITLE:          AN ADA SOFTWARE METRIC                     --
--                                                             --
--  MODULE NAME:    PACKAGE PARSER_2                           --
--  DATE CREATED:   18 JUL 86                                  --
--  LAST MODIFIED:  04 DEC 86                                  --
--                                                             --
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--                  LT KARL S. FAIRBANKS, JR.                  --
--                                                             --
--  DESCRIPTION:  This package contains thirty-three functions --
--       that are the middle level productions for our top-down, --
--       recursive descent parser.  Each function is preceded  --
--       by the grammaar productions they are implementing.    --
--                                                             --
--*************************************************************--

with PARSER_3, PARSER_4, BYPASS_FUNCTION, BYPASS_SUPPORT_FUNCTIONS,
       GLOBAL_PARSER, GLOBAL;
use PARSER_3, PARSER_4, BYPASS_FUNCTION, BYPASS_SUPPORT_FUNCTIONS,
      GLOBAL_PARSER, GLOBAL;

package PARSER_2 is
   function GENERIC_ACTUAL_PART return boolean;
   function GENERIC_ASSOCIATION return boolean;
   function GENERIC_FORMAL_PARAMETER return boolean;
   function GENERIC_TYPE_DEFINITION return boolean;
   function PRIVATE_TYPE_DECLARATION return boolean;
   function TYPE_DECLARATION return boolean;
   function SUBTYPE_DECLARATION return boolean;
   function DISCRIMINANT_PART return boolean;
   function DISCRIMINANT_SPECIFICATION return boolean;
   function TYPE_DEFINITION return boolean;
   function RECORD_TYPE_DEFINITION return boolean;
   function COMPONENT_LIST return boolean;
   function COMPONENT_DECLARATION return boolean;
   function VARIANT_PART return boolean;
   function VARIANT return boolean;
   function WITH_OR_USE_CLAUSE return boolean;
   function FORMAL_PART return boolean;
   function IDENTIFIER_DECLARATION return boolean;
   function IDENTIFIER_DECLARATION_TAIL return boolean;
   function EXCEPTION_TAIL return boolean;
   function EXCEPTION_CHOICE return boolean;
   function CONSTANT_TERM return boolean;
   function IDENTIFIER_TAIL return boolean;
   function PARAMETER_SPECIFICATION return boolean;
   function IDENTIFIER_LIST return boolean;
   function MODE return boolean;
   function DESIGNATOR return boolean;
   function SIMPLE_STATEMENT return boolean;
   function ASSIGNMENT_OR_PROCEDURE_CALL return boolean;
   function LABEL return boolean;
   function ENTRY_DECLARATION return boolean;
   function REPRESENTATION_CLAUSE return boolean;
   function RECORD_REPRESENTATION_CLAUSE return boolean;
end PARSER_2;

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package body PARSER_2 is

   -- GENERIC_ACTUAL_PART -->  (GENERIC_ASSOCIATION [, GENERIC_ASSOCIATION]* )
function GENERIC_ACTUAL_PART return boolean is
begin
   if (BYPASS(TOKEN_LEFT_PAREN)) then
      if (GENERIC_ASSOCIATION) then
         while (BYPASS(TOKEN_COMMA)) loop
            if not (GENERIC_ASSOCIATION) then
               SYNTAX_ERROR("Generic actual part");
            end if;                        -- if not generic_association
         end loop;
         if (BYPASS(TOKEN_RIGHT_PAREN)) then
            return (TRUE);
         else
            SYNTAX_ERROR("Generic actual part");
         end if;                           -- if bypass(token_right_paren)
      else
         SYNTAX_ERROR("Generic actual part");
      end if;                             -- if generic association statement
   else
      return(FALSE);
   end if;                               -- if bypass(token_left_paren)
end GENERIC_ACTUAL_PART;

---------------------------------------------------------------------------------

   -- GENERIC_ASSOCIATION -->  [GENERIC_FORMAL_PARAMETER ?] EXPRESSION
function GENERIC_ASSOCIATION return boolean is
begin
   if (GENERIC_FORMAL_PARAMETER) then
      null;
   end if;                               -- if generic_formal_parameter statement
   if (EXPRESSION) then                  -- check for generic_actual_parameter
      return (TRUE);
   else
      return (FALSE);
   end if;                               -- if expression
end GENERIC_ASSOCIATION;

---------------------------------------------------------------------------------

   -- GENERIC_FORMAL_PARAMETER -->  identifier =>
   --                          -->  string_literal =>
function GENERIC_FORMAL_PARAMETER return boolean is
begin
   LOOK_AHEAD_TOKEN := TOKEN_RECORD_BUFFER(TOKEN_ARRAY_INDEX + 1);
   if (ADJUST_LEXEME(LOOK_AHEAD_TOKEN.LEXEME,
                           LOOK_AHEAD_TOKEN.LEXEME_SIZE - 1) = "=>") then
      if (BYPASS(TOKEN_IDENTIFIER)) then
         if (BYPASS(TOKEN_ARROW)) then
            return (TRUE);
         else
            SYNTAX_ERROR("Generic formal parameter");
         end if;                         -- if bypass(token_arrow)
      elsif (BYPASS(TOKEN_STRING_LITERAL)) then
         if (BYPASS(TOKEN_ARROW)) then
            return (TRUE);
         else
            SYNTAX_ERROR("Generic formal parameter");
         end if;                         -- if bypass(token_arrow)
      else
         SYNTAX_ERROR("Generic formal parameter");
      end if;                            -- if bypass(token_identifier)
   else
      return (FALSE);
   end if;                               -- if adjust_lexeme(lookahead_token)
end GENERIC_FORMAL_PARAMETER;
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--------------------------------------------------------------------------------

   -- GENERIC_TYPE_DEFINITION -->  ( <> )
   --                         -->  range <>
   --                         -->  digits <>
   --                         -->  delta <>
   --                         -->  array ARRAY_TYPE_DEFINITION
   --                         -->  access SUBTYPE_INDICATION
function GENERIC_TYPE_DEFINITION return boolean is
begin
   if (BYPASS(TOKEN_LEFT_PAREN)) then
      if (BYPASS(TOKEN_BRACKETS)) then
         if (BYPASS(TOKEN_RIGHT_PAREN)) then
            return (TRUE);
         else
            SYNTAX_ERROR("Generic type definition");
         end if;                        -- if bypass(token_right_paren)
      else
         SYNTAX_ERROR("Generic type definition");
      end if;                           -- if bypass(token_brackets)
   elsif (BYPASS(TOKEN_RANGE)) or else (BYPASS(TOKEN_DIGITS))
      or else (BYPASS(TOKEN_DELTA)) then
      if (BYPASS(TOKEN_BRACKETS)) then
         return (TRUE);
      else
         SYNTAX_ERROR("Generic type definition");
      end if;                           -- if bypass(token_brackets)
   elsif (BYPASS(TOKEN_ARRAY)) then
      if (ARRAY_TYPE_DEFINITION) then
         return (TRUE);
      else
         SYNTAX_ERROR("Generic type definition");
      end if;                           -- if array_type_definition
   elsif (BYPASS(TOKEN_ACCESS)) then
      if (SUBTYPE_INDICATION) then
         return (TRUE);
      else
         SYNTAX_ERROR("Generic type definition");
      end if;                           -- if subtype_indication
   else
      return (FALSE);
   end if;                              -- if bypass(token_left_paren)
end GENERIC_TYPE_DEFINITION;

--------------------------------------------------------------------------------

   -- PRIVATE_TYPE_DECLARATION -->  [limited ?] private
function PRIVATE_TYPE_DECLARATION return boolean is
begin
   if (BYPASS(TOKEN_LIMITED)) then
      null;
   end if;
   if (BYPASS(TOKEN_PRIVATE)) then
      return (TRUE);
   else
      return (FALSE);
   end if;
end PRIVATE_TYPE_DECLARATION;

--------------------------------------------------------------------------------

   -- SUBTYPE_DECLARATION -->  identifier is SUBTYPE_INDICATION ;
function SUBTYPE_DECLARATION return boolean is
begin
   if (BYPASS(TOKEN_IDENTIFIER)) then
      if (BYPASS(TOKEN_IS)) then
         if (SUBTYPE_INDICATION) then
            if (BYPASS(TOKEN_SEMICOLON)) then
```

```
            return (TRUE);
         else
            SYNTAX_ERROR("Subtype declaration");
         end if;                        -- if bypass(token_semicolon)
      else
         SYNTAX_ERROR("Subtype declaration");
      end if;                           -- if subtype_indication statement
   else
      SYNTAX_ERROR("Subtype declaration");
   end if;                              -- if bypass(token_is)
else
   return (FALSE);
end if;                                 -- if bypass(token_identifier)
end SUBTYPE_DECLARATION;

---------------------------------------------------------------------------------

   -- TYPE_DECLARATION -->  identifier [DISCRIMINANT_PART ?]
   --                          is SUBTYPE_INDICATION;
function TYPE_DECLARATION return boolean is
begin
   if (BYPASS(TOKEN_IDENTIFIER)) then
      if (DISCRIMINANT_PART) then
         null;
      end if;                           -- if discriminant_part statement
      if (BYPASS(TOKEN_IS)) then        -- declaration is full_type if 'is'
         if (PRIVATE_TYPE_DECLARATION) then
            null;
         elsif (TYPE_DEFINITION) then    --    present, otherwise incomplete_type
            null;
         else
            SYNTAX_ERROR("Type declaration");
         end if;                        -- if type_definition statement
      end if;                           -- if bypass(token_is)
      if (BYPASS(TOKEN_SEMICOLON)) then
         return (TRUE);
      else
         SYNTAX_ERROR("Type declaration");
      end if;                           -- if bypass(token_semicolon)
   else
      return (FALSE);
   end if;                              -- if bypass(token_identifier)
end TYPE_DECLARATION;

----------------------------------------------------------------------- -------

   -- DISCRIMINANT_PART -->  (DISCRIMINANT_SPECIFICATION
   --                          [; DISCRIMINANT_SPECIFICATION]* )
function DISCRIMINANT_PART return boolean is
begin
   if (BYPASS(TOKEN_LEFT_PAREN)) then
      if (DISCRIMINANT_SPECIFICATION) then
         while (BYPASS(TOKEN_SEMICOLON)) loop
            if not (DISCRIMINANT_SPECIFICATION) then
               SYNTAX_ERROR("Discriminant part");
            end if;                     -- if not discriminant_specification
         end loop;
         if (BYPASS(TOKEN_RIGHT_PAREN)) then
            return (TRUE);
         else
            SYNTAX_ERROR("Discriminant part");
         end if;                        -- if bypass(token_right_paren)
      else
         SYNTAX_ERROR("Discriminant part");
      end if;                           -- if discriminant_specification
   else
      return (FALSE);
   end if;                              -- if bypass(token_left_paren)
end DISCRIMINANT_PART;
```

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   -- DISCRIMINANT_SPECIFICATION -->  IDENTIFIER_LIST : NAME [:= EXPRESSION ?]
function DISCRIMINANT_SPECIFICATION return boolean is
begin
   if (IDENTIFIER_LIST) then
      if (BYPASS(TOKEN_COLON)) then
         if (NAME) then                        -- check for type_mark
            if (BYPASS(TOKEN_ASSIGNMENT)) then
               if (EXPRESSION) then
                  null;
               else
                  SYNTAX_ERROR("Discriminant specification");
               end if;                            -- if expression statement
            end if;                              -- if bypass(token_assignment)
            return (TRUE);
         else
            SYNTAX_ERROR("Discriminant specification");
         end if;                               -- if name statement
      else
         SYNTAX_ERROR("Discriminant specification");
      end if;                                 -- if bypass(token_colon)
   else
      return (FALSE);
   end if;                                   -- if identifier_list statement
end DISCRIMINANT_SPECIFICATION;

--------------------------------------------------------------------------------

   -- TYPE_DEFINITION -->  ENUMERATION_TYPE_DEFINITION
   --                  -->  INTEGER_TYPE_DEFINITION
   --                  -->  digits FLOATING_OR_FIXED_POINT_CONSTRAINT
   --                  -->  delta FLOATING_OR_FIXED_POINT_CONSTRAINT
   --                  -->  array ARRAY_TYPE_DEFINITION
   --                  -->  record RECORD_TYPE_DEFINITION
   --                  -->  access SUBTYPE_INDICATION
   --                  -->  new SUBTYPE_INDICATION
function TYPE_DEFINITION return boolean is
begin
   if (ENUMERATION_TYPE_DEFINITION) then
      return (TRUE);
   elsif (INTEGER_TYPE_DEFINITION) then
      return (TRUE);
   elsif (BYPASS(TOKEN_DIGITS)) or else (BYPASS(TOKEN_DELTA)) then
      if (FLOATING_OR_FIXED_POINT_CONSTRAINT) then
         return (TRUE);
      else
         SYNTAX_ERROR("Type definition");
      end if;                                 -- floating_or_fixed_point_constraint
   elsif (BYPASS(TOKEN_ARRAY)) then
      if (ARRAY_TYPE_DEFINITION) then
         return (TRUE);
      else
         SYNTAX_ERROR("Type definition");
      end if;                                 -- if array_type_definition
   elsif (BYPASS(TOKEN_RECORD_STRUCTURE)) then
      if (RECORD_TYPE_DEFINITION) then
         return (TRUE);
      else
         SYNTAX_ERROR("Type definition");
      end if;                                 -- if record_type_definition
   elsif (BYPASS(TOKEN_ACCESS)) or else (BYPASS(TOKEN_NEW)) then
      if (SUBTYPE_INDICATION) then
         return (TRUE);
      else
         SYNTAX_ERROR("Type definition");
      end if;                                 -- if subtype_indication
   else
```

```
      return (FALSE);
   end if;
end TYPE_DEFINITION;

--------------------------------------------------------------------------------

   -- RECORD_TYPE_DEFINITION -->  COMPONENT_LIST end record
function RECORD_TYPE_DEFINITION return boolean is
begin
   if (COMPONENT_LIST) then
      if (BYPASS(TOKEN_END)) then
         if (BYPASS(TOKEN_RECORD_STRUCTURE)) then
            return (TRUE);
         else
            SYNTAX_ERROR("Record type definition");
         end if;                          -- if bypass(token_record-structure)
      else
         SYNTAX_ERROR("Record type definition");
      end if;                             -- if bypass(token_end)
   else
      return (FALSE);
   end if;                             -- if component_list statement
end RECORD_TYPE_DEFINITION;

--------------------------------------------------------------------------------

   -- COMPONENT_LIST -->  [COMPONENT_DECLARATION]* [VARIANT_PART ?]
   --                 -->  null ;
function COMPONENT_LIST return boolean is
begin
   while (COMPONENT_DECLARATION) loop
      null;
   end loop;
   if (VARIANT_PART) then
      null;
   elsif (BYPASS(TOKEN_NULL)) then
      if (BYPASS(TOKEN_SEMICOLON)) then
         null;
      end if;
   end if;
   return (TRUE);
end COMPONENT_LIST;

--------------------------------------------------------------------------------

   -- COMPONENT_DECLARATION -->  IDENTIFIER_LIST : SUBTYPE_INDICATION
   --                            [:= EXPRESSION ?] ;
function COMPONENT_DECLARATION return boolean is
begin
   if (IDENTIFIER_LIST) then
      if (BYPASS(TOKEN_COLON)) then
         if (SUBTYPE_INDICATION) then
            if (BYPASS(TOKEN_ASSIGNMENT)) then
               if (EXPRESSION) then
                  if (BYPASS(TOKEN_SEMICOLON)) then
                     return (TRUE);
                  else
                     SYNTAX_ERROR("Component declaration");
                  end if;                     -- if bypass(token_semicolon)
               else
                  SYNTAX_ERROR("Component declaration");
               end if;                        -- if expression statement
            end if;                           -- if bypass(token_assignment)
            if (BYPASS(TOKEN_SEMICOLON)) then
               return (TRUE);
            else
               SYNTAX_ERROR("Component declaration");
            end if;                           -- if bypass(token_semicolon)
         else
```

```
            SYNTAX_ERROR("Component declaration");
         end if;                              -- if subtype_indication statement
      else
         SYNTAX_ERROR("Component declaration");
      end if;                                 -- if bypass(token_colon)
   else
      return (FALSE);
   end if;                                    -- if identifier_list statement
end COMPONENT_DECLARATION;

-----------------------------------------------------------------------------

   -- VARIANT_PART --> case identifier is [VARIANT]+ end case ;
function VARIANT_PART return boolean is
begin
   if (BYPASS(TOKEN_CASE)) then
      if (BYPASS(TOKEN_IDENTIFIER)) then
         if (BYPASS(TOKEN_IS)) then
            if (VARIANT) then
               while (VARIANT) loop
                  null;
               end loop;
               if (BYPASS(TOKEN_END)) then
                  if (BYPASS(TOKEN_CASE)) then
                     if (BYPASS(TOKEN_SEMICOLON)) then
                        return (TRUE);
                     else
                        SYNTAX_ERROR("Variant part");
                     end if;                  -- if bypass(token_semicolon)
                  else
                     SYNTAX_ERROR("Variant part");
                  end if;                     -- if bypass(token_case)
               else
                  SYNTAX_ERROR("Variant part");
               end if;                        -- if bypass(token_end)
            else
               SYNTAX_ERROR("Variant part");
            end if;                           -- if variant statement
         else
            SYNTAX_ERROR("Variant part");
         end if;                              -- if bypass(token_is)
      else
         SYNTAX_ERROR("Variant part");
      end if;                                 -- if bypass(token_identifier)
   else
      return (FALSE);
   end if;                                    -- if bypass(token_case)
end VARIANT_PART;

-----------------------------------------------------------------------------

   -- VARIANT --> when CHOICE [  CHOICE]* => COMPONENT_LIST
function VARIANT return boolean is
begin
   if (BYPASS(TOKEN_WHEN)) then
      if (CHOICE) then
         while (BYPASS(TOKEN_BAR)) loop
            if not (CHOICE) then
               SYNTAX_ERROR("Variant");
            end if;                           -- if not choice statement
         end loop;
         if (BYPASS(TOKEN_ARROW)) then
            if (COMPONENT_LIST) then
               return (TRUE);
            else
               SYNTAX_ERROR("Variant");
            end if;                           -- if component_list statement
         else
            SYNTAX_ERROR("Variant");
```

```
         end if;                                  -- if bypass(token_arrow)
      else
         SYNTAX_ERROR("Variant");
      end if;                                   -- if choice statement
   else
      return (FALSE);
   end if;                                     -- if bypass(token_when)
end VARIANT;

-------------------------------------------------------------------------------

   -- WITH_OR_USE_CLAUSE -->  identifier [, identifier]* ;
function WITH_OR_USE_CLAUSE return boolean is
begin
   if (BYPASS(TOKEN_IDENTIFIER)) then
      while (BYPASS(TOKEN_COMMA)) loop
         if not (BYPASS(TOKEN_IDENTIFIER)) then
            SYNTAX_ERROR("With or use clause");
         end if;
      end loop;
      if (BYPASS(TOKEN_SEMICOLON)) then
         return (TRUE);
      else
         SYNTAX_ERROR("With or use clause");
      end if;                                   -- if bypass(token_semicolon)
   else
      return (FALSE);
   end if;                                     -- if bypass(token_identifier)
end WITH_OR_USE_CLAUSE;

-------------------------------------------------------------------------------

   -- FORMAL_PART -->  (PARAMETER_SPECIFICATION [; PARAMETER_SPECIFICATION]* )
function FORMAL_PART return boolean is
begin
   if (BYPASS(TOKEN_LEFT_PAREN)) then
      if (PARAMETER_SPECIFICATION) then
         while (BYPASS(TOKEN_SEMICOLON)) loop
            if not (PARAMETER_SPECIFICATION) then
               SYNTAX_ERROR("Formal part");
            end if;                       -- if not parameter_specification statement
         end loop;
         if (BYPASS(TOKEN_RIGHT_PAREN)) then
            return (TRUE);
         else
            SYNTAX_ERROR("Formal part");
         end if;                          -- if bypass(token_right_paren) statement
      else
         SYNTAX_ERROR("Formal part");
      end if;                            -- if parameter_specification statement
   else
      return (FALSE);
   end if;                              -- if bypass(token_left_paren) statement
end FORMAL_PART;

-------------------------------------------------------------------------------

   -- IDENTIFIER_DECLARATION -->  IDENTIFIER_LIST : IDENTIFIER_DECLARATION_TAIL
function IDENTIFIER_DECLARATION return boolean is
begin
   if (IDENTIFIER_LIST) then
      if (BYPASS(TOKEN_COLON)) then
         if (IDENTIFIER_DECLARATION_TAIL) then
            return (TRUE);
         else
            SYNTAX_ERROR("Identifier declaration");
         end if;                            -- if identifier list statement
      else
         SYNTAX_ERROR("Identifier declaration");
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         end if;                          -- if bypass(token_colon)
      else
         return(FALSE);
      end if;                           -- if identifier list statement
   end IDENTIFIER_DECLARATION;

   ----------------------------------------------------------------------------

      -- IDENTIFIER_DECLARATION_TAIL -->  exception EXCEPTION_TAIL
      --                             -->  constant CONSTANT_TERM
      --                             -->  array ARRAY_TYPE_DEFINITION
      --                                    [:= EXPRESSION ?] ;
      --                             -->  NAME  IDENTIFIER_TAIL
   function IDENTIFIER_DECLARATION_TAIL return boolean is
   begin
      if (BYPASS(TOKEN_EXCEPTION)) then
         if (EXCEPTION_TAIL) then
            return (TRUE);
         else
            SYNTAX_ERROR("Identifier declaration tail");
         end if;                              -- if exception tail statement
      elsif (BYPASS(TOKEN_CONSTANT)) then
         if (CONSTANT_TERM) then
            return (TRUE);
         else
            SYNTAX_ERROR("Identifier declaration tail");
         end if;                              -- if constant_term statement
      elsif (BYPASS(TOKEN_ARRAY)) then
         if (ARRAY_TYPE_DEFINITION) then
            if (BYPASS(TOKEN_ASSIGNMENT)) then
               if (EXPRESSION) then
                  null;
               else
                  SYNTAX_ERROR("Identifier declaration tail");
               end if;                          -- if expression statement
            end if;                            -- if bypass(token_assignment)
         else
            SYNTAX_ERROR("Identifier declaration tail");
         end if;                              -- if array_type_definition
         if (BYPASS(TOKEN_SEMICOLON)) then
            return (TRUE);
         else
            SYNTAX_ERROR("Identifier declaration tail");
         end if;                              -- if bypass(token_semicolon)
      elsif (NAME) then
         if (IDENTIFIER_TAIL) then
            return (TRUE);
         else
            SYNTAX_ERROR("Identifier declaration tail");
         end if;                              -- if identifier_tail
      else
         return (FALSE);
      end if;                               -- if bypass(token_exception)
   end IDENTIFIER_DECLARATION_TAIL;

   ----------------------------------------------------------------------------

      -- EXCEPTION_TAIL -->  ;
      --                -->  renames NAME ;
   function EXCEPTION_TAIL return boolean is
   begin
      if (BYPASS(TOKEN_SEMICOLON)) then
         return (TRUE);
      elsif (BYPASS(TOKEN_RENAMES)) then
         if (NAME) then
            if (BYPASS(TOKEN_SEMICOLON)) then
               return (TRUE);
            else
               SYNTAX_ERROR("Exception tail");
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```
         end if;                                     -- if bypass(token_semicolon)
      else
         SYNTAX_ERROR("Exception tail");
      end if;                                        -- if name statement
   else
      return (FALSE);
   end if;                                           -- if bypass(token_semicolon)
end EXCEPTION_TAIL;

-------------------------------------------------------------------------------

   -- EXCEPTION_CHOICE -->  identifier
   --                  -->  others
function EXCEPTION_CHOICE return boolean is
begin
   if (BYPASS(TOKEN_IDENTIFIER)) then
      return (TRUE);
   elsif (BYPASS(TOKEN_OTHERS)) then
      return (TRUE);
   else
      return (FALSE);
   end if;
end EXCEPTION_CHOICE;

-------------------------------------------------------------------------------

   -- CONSTANT_TERM -->  array ARRAY_TYPE_DEFINITION [:= EXPRESSION ?] ;
   --               -->  := EXPRESSION ;
   --               -->  NAME  IDENTIFIER_TAIL
function CONSTANT_TERM return boolean is
begin
   if (BYPASS(TOKEN_ARRAY)) then
      if (ARRAY_TYPE_DEFINITION) then
         if (BYPASS(TOKEN_ASSIGNMENT)) then
            if (EXPRESSION) then
               null;
            else
               SYNTAX_ERROR("Constant term");
            end if;                                  -- if expression statement
         end if;                                     -- if bypass(token_assignment)
      else
         SYNTAX_ERROR("Constant term");
      end if;                                        -- if array_type_definition
      if (BYPASS(TOKEN_SEMICOLON)) then
         return (TRUE);
      else
         SYNTAX_ERROR("Constant term");
      end if;                                        -- if bypass(token_semicolon)
   elsif (BYPASS(TOKEN_ASSIGNMENT)) then
      if (EXPRESSION) then
         if (BYPASS(TOKEN_SEMICOLON)) then
            return (TRUE);
         else
            SYNTAX_ERROR("Constant term");
         end if;                                     -- if bypass(token_semicolon)
      else
         SYNTAX_ERROR("Constant term");
      end if;                                        -- if expression statement
   elsif (NAME) then
      if (IDENTIFIER_TAIL) then
         return (TRUE);
      else
         SYNTAX_ERROR("Constant term");
      end if;                                        -- if identifier_tail statement
   else
      return (FALSE);
   end if;                                           -- if bypass(token_array)
end CONSTANT_TERM;
```

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--------------------------------------------------------------------------------

   -- IDENTIFIER_TAIL -->  [CONSTRAINT ?] [:= EXPRESSION ?] ;
   --                 -->  [renames NAME ?] ;
function IDENTIFIER_TAIL return boolean is
begin
   if (CONSTRAINT) then
      null;
   end if;                              -- if constraint statement
   if (BYPASS(TOKEN_RENAMES)) then
      if (NAME) then
         null;
      else
         SYNTAX_ERROR("Identifier tail");
      end if;                           -- if name statement
   end if;                              -- if bypass(token_renames)
   if (BYPASS(TOKEN_ASSIGNMENT)) then
      if (EXPRESSION) then
         null;
      else
         SYNTAX_ERROR("Identifier tail");
      end if;                           -- if expression statement
   end if;                              -- if bypass(token_assignment)
   if (BYPASS(TOKEN_SEMICOLON)) then
      return (TRUE);
   else
      return (FALSE);
   end if;                              -- if bypass(token_semicolon)
end IDENTIFIER_TAIL;

--------------------------------------------------------------------------------

   -- PARAMETER_SPECIFICATION -->  IDENTIFIER_LIST : MODE  NAME [:= EXPRESSION ?]
function PARAMETER_SPECIFICATION return boolean is
begin
   if (IDENTIFIER_LIST) then
      if (BYPASS(TOKEN_COLON)) then
         if (MODE) then
            if (NAME) then                 -- check for type_mark
               if (BYPASS(TOKEN_ASSIGNMENT)) then
                  if (EXPRESSION) then
                     null;
                  else
                     SYNTAX_ERROR("Parameter specification");
                  end if;                  -- if expression statement
               end if;                     -- if bypass(token_assignment)
               return (TRUE);
            else
               SYNTAX_ERROR("Parameter specification");
            end if;                        -- if name statement
         else
            SYNTAX_ERROR("Parameter specification");
         end if;                           -- if mode statement
      else
         SYNTAX_ERROR("Parameter specification");
      end if;                              -- if bypass(token_colon)
   else
      return (FALSE);
   end if;                                 -- if identifier_list statement
end PARAMETER_SPECIFICATION;

--------------------------------------------------------------------------------

   -- IDENTIFIER_LIST -->  identifier [, identifier]*
function IDENTIFIER_LIST return boolean is
begin
   if (BYPASS(TOKEN_IDENTIFIER)) then
      while (BYPASS(TOKEN_COMMA)) loop
         if not (BYPASS(TOKEN_IDENTIFIER)) then
```

```
         SYNTAX_ERROR("Identifier list");
      end if;                       -- if not bypass(token_identifer) statement
   end loop;
   return (TRUE);
else
   return (FALSE);
end if;                       -- if bypass(token_identifier) statement
end IDENTIFIER_LIST;

--------------------------------------------------------------------------------

   -- MODE -->  [in ?]
   --      -->  in out
   --      -->  out
function MODE return boolean is
begin
   if (BYPASS(TOKEN_IN)) then
      if (BYPASS(TOKEN_OUT)) then
         null;
      end if;
   elsif (BYPASS(TOKEN_OUT)) then
      null;
   end if;
   return (TRUE);
end MODE;

--------------------------------------------------------------------------------

   -- DESIGNATOR -->  identifier
   --            -->  string_literal
function DESIGNATOR return boolean is
begin
   if (BYPASS(TOKEN_IDENTIFIER)) then
      return (TRUE);
   elsif (BYPASS(TOKEN_STRING_LITERAL)) then
      return (TRUE);
   else
      return (FALSE);
   end if;
end DESIGNATOR;

--------------------------------------------------------------------------------

   -- SIMPLE_STATEMENT -->  null ;
   --                  -->  ASSIGNMENT_OR_PROCEDURE_CALL
   --                  -->  exit EXIT_STATEMENT
   --                  -->  return RETURN_STATEMENT
   --                  -->  goto GOTO_STATEMENT
   --                  -->  delay DELAY_STATEMENT
   --                  -->  abort ABORT_STATEMENT
   --                  -->  raise RAISE_STATEMENT
function SIMPLE_STATEMENT return boolean is
begin
   if (BYPASS(TOKEN_NULL)) then
      if (BYPASS(TOKEN_SEMICOLON)) then
         return (TRUE);
      else
         SYNTAX_ERROR("Simple statement");
      end if;
   elsif (ASSIGNMENT_OR_PROCEDURE_CALL) then      -- includes a check for a
      return (TRUE);                               --    code statement and an
                                                                --    entry call statement.
   elsif (BYPASS(TOKEN_EXIT)) then
      if (EXIT_STATEMENT) then
         return (TRUE);
      else
         SYNTAX_ERROR("Simple statement");
      end if;
   elsif (BYPASS(TOKEN_RETURN)) then
```

```
      if (RETURN_STATEMENT) then
         return (TRUE);
      else
         SYNTAX_ERROR("Simple statement");
      end if;
   elsif (BYPASS(TOKEN_GOTO)) then
      if (GOTO_STATEMENT) then
         return (TRUE);
      else
         SYNTAX_ERROR("Simple statement");
      end if;
   elsif (BYPASS(TOKEN_DELAY)) then
      if (DELAY_STATEMENT) then
         return (TRUE);
      else
         SYNTAX_ERROR("Simple statement");
      end if;
   elsif (BYPASS(TOKEN_ABORT)) then
      if (ABORT_STATEMENT) then
         return (TRUE);
      else
         SYNTAX_ERROR("Simple statement");
      end if;
   elsif (BYPASS(TOKEN_RAISE)) then
      if (RAISE_STATEMENT) then
         return (TRUE);
      else
         SYNTAX_ERROR("Simple statement");
      end if;
   else
      return (FALSE);
   end if;
end SIMPLE_STATEMENT;

---------------------------------------------------------------------------

   -- ASSIGNMENT_OR_PROCEDURE_CALL --> NAME := EXPRESSION ;
   --                              --> NAME ;
function ASSIGNMENT_OR_PROCEDURE_CALL return boolean is
begin
   if (NAME) then
      if (BYPASS(TOKEN_ASSIGNMENT)) then
         if (EXPRESSION) then
            if (BYPASS(TOKEN_SEMICOLON)) then
               return (TRUE);             -- parsed an assignment statement
            else
               SYNTAX_ERROR("Assignment or procedure call");
            end if;                     -- if bypass(token_semicolon)
         else
            SYNTAX_ERROR("Assignment or procedure call");
         end if;                        -- if expression statement
      elsif (BYPASS(TOKEN_SEMICOLON)) then
         return (TRUE);                 -- parsed a procedure call statement
      else
         SYNTAX_ERROR("Assignment or procedure call");
      end if;                          -- if bypass(token_assignment)
   else
      return (FALSE);
   end if;                             -- if name statement
end ASSIGNMENT_OR_PROCEDURE_CALL;

---------------------------------------------------------------------------

   -- LABEL --> << identifier >>
function LABEL return boolean is
begin
   if (BYPASS(TOKEN_LEFT_BRACKET)) then
      if (BYPASS(TOKEN_IDENTIFIER)) then
         if (BYPASS(TOKEN_RIGHT_BRACKET)) then
```

```
            return (TRUE);
         else
            SYNTAX_ERROR("Label");
         end if;                          -- if bypass(token_right_bracket)
      else
         SYNTAX_ERROR("Label");
      end if;                             -- if bypasss(token_identifier)
   else
      return (FALSE);
   end if;                                -- if bypass(token_left_bracket)
end LABEL;

-----------------------------------------------------------------------------

   -- ENTRY_DECLARATION -->  entry identifier [(DISCRETE_RANGE) ?]
   --                              [FORMAL_PART ?] ;
function ENTRY_DECLARATION return boolean is
begin
   if (BYPASS(TOKEN_ENTRY)) then
      if (BYPASS(TOKEN_IDENTIFIER)) then
         if (BYPASS(TOKEN_LEFT_PAREN)) then
            if (DISCRETE_RANGE) then
               if (BYPASS(TOKEN_RIGHT_PAREN)) then
                  null;
               else
                  SYNTAX_ERROR("Entry declaration");
               end if;                    -- if bypass(token_right_paren)
            else
               SYNTAX_ERROR("Entry declaration");
            end if;                       -- if discrete_range statement
         end if;                          -- if bypass(token_left_paren)
         if (FORMAL_PART) then
            null;
         end if;                          -- if formal_part statement
         if (BYPASS(TOKEN_SEMICOLON)) then
            return (TRUE);
         else
            SYNTAX_ERROR("Entry declaration");
         end if;                          -- if bypass(token_semicolon)
      else
         SYNTAX_ERROR("Entry declaration");
      end if;                             -- if bypass(token_identifier)
   else
      return (FALSE);
   end if;                                -- if bypass(token_entry)
end ENTRY_DECLARATION;

-----------------------------------------------------------------------------

   -- REPRESENTATION_CLAUSE -->  for NAME use record RECORD_REPRESENTATION_CLAUSE
   --                       -->  for NAME use [at ?] SIMPLE_EXPRESSION;
function REPRESENTATION_CLAUSE return boolean is
begin
   if (BYPASS(TOKEN_FOR)) then
      if (NAME) then
         if (BYPASS(TOKEN_USE)) then
            if (BYPASS(TOKEN_RECORD_STRUCTURE)) then
               if (RECORD_REPRESENTATION_CLAUSE) then
                  return (TRUE);
               else
                  SYNTAX_ERROR("Representation clause");
               end if;                    -- if record_representation_clause
            elsif (BYPASS(TOKEN_AT)) then
               if (SIMPLE_EXPRESSION) then
                  if (BYPASS(TOKEN_SEMICOLON)) then
                     return (TRUE);
                  else
                     SYNTAX_ERROR("Representation clause");
                  end if;                 -- if bypass(token_semicolon)
```

```
            else
               SYNTAX_ERROR("Representation clause");
            end if;                          -- if simple_expression statement
         elsif (SIMPLE_EXPRESSION) then
            if (BYPASS(TOKEN_SEMICOLON)) then
               return (TRUE);
            else
               SYNTAX_ERROR("Representation clause");
            end if;                          -- if bypass(token_semicolon)
         else
            SYNTAX_ERROR("Representation clause");
         end if;                             -- if bypass(token_record)
      else
         SYNTAX_ERROR("Representation clause");
      end if;                                -- if bypass(token_use)
   else
      SYNTAX_ERROR("Representation clause");
   end if;                                   -- if name statement
else
   return (FALSE);
end if;                                      -- if bypass(token_for)
end REPRESENTATION_CLAUSE;

--------------------------------------------------------------------------------

   -- RECORD_REPRESENTATION_CLAUSE -->  [at mod SIMPLE_EXPRESSION ?]
   --                                   [NAME at SIMPLE_EXPRESSION range RANGES]*
   --                                   end record ;
function RECORD_REPRESENTATION_CLAUSE return boolean is
begin
   if (BYPASS(TOKEN_AT)) then
      if (BYPASS(TOKEN_MOD)) then
         if (SIMPLE_EXPRESSION) then
            null;
         else
            SYNTAX_ERROR("Record representation clause");
         end if;                             -- if simple_expression
      else
         SYNTAX_ERROR("Record representation clause");
      end if;                                -- if bypass(token_mod)
   end if;                                   -- if bypass(token_at)
   while (NAME) loop
      if (BYPASS(TOKEN_AT)) then
         if (SIMPLE_EXPRESSION) then
            if (BYPASS(TOKEN_RANGE)) then
               if (RANGES) then
                  null;
               else
                  SYNTAX_ERROR("Record representation clause");
               end if;                       -- if ranges statement
            else
               SYNTAX_ERROR("Record representation clause");
            end if;                          -- if bypass(token_range)
         else
            SYNTAX_ERROR("Record representation clause");
         end if;                             -- if simple_expression
      else
         SYNTAX_ERROR("Record representation clause");
      end if;                                -- if bypass(token_at)
   end loop;
   if (BYPASS(TOKEN_END)) then
      if (BYPASS(TOKEN_RECORD_STRUCTURE)) then
         if (BYPASS(TOKEN_SEMICOLON)) then
            return (TRUE);
         else
            SYNTAX_ERROR("Record representation clause");
         end if;                             -- if bypass(token_semicolon)
      else
         SYNTAX_ERROR("Record representation clause");
```

```
      end if;                                -- if bypass(token_record_structure)
   else
      return (FALSE);
   end if;                                -- if bypass(token_end)
end RECORD_REPRESENTATION_CLAUSE;

end PARSER_2;
```

```
--**********************************************************--
--                                                          --
--  TITLE:          AN ADA SOFTWARE METRIC                  --
--                                                          --
--  MODULE NAME:    PACKAGE PARSER_3                        --
--  DATE CREATED:   22 JUL 86                               --
--  LAST MODIFIED:  03 DEC 86                               --
--                                                          --
--  AUTHORS:        LCDR JEFFREY L. NIEDER                  --
--                  LT KARL S. FAIRBANKS, JR.               --
--                                                          --
--  DESCRIPTION:  This package contains thirty-five functions  --
--       that make up the baseline productions for our top-down, --
--       recursive descent parser.  Each function is preceded   --
--       by the grammar productions they are implementing.      --
--                                                          --
--**********************************************************--

with PARSER_4, BYPASS_FUNCTION, HALSTEAD_METRIC, GLOBAL_PARSER, GLOBAL;
use PARSER_4, BYPASS_FUNCTION, HALSTEAD_METRIC, GLOBAL_PARSER, GLOBAL;

package PARSER_3 is
   function SUBTYPE_INDICATION return boolean;
   function ARRAY_TYPE_DEFINITION return boolean;
   function CHOICE return boolean;
   function ITERATION_SCHEME return boolean;
   function LOOP_PARAMETER_SPECIFICATION return boolean;
   function EXPRESSION return boolean;
   function RELATION return boolean;
   function RELATION_TAIL return boolean;
   function SIMPLE_EXPRESSION return boolean;
   function SIMPLE_EXPRESSION_TAIL return boolean;
   function TERM return boolean;
   function FACTOR return boolean;
   function PRIMARY return boolean;
   function CONSTRAINT return boolean;
   function FLOATING_OR_FIXED_POINT_CONSTRAINT return boolean;
   function INDEX_CONSTRAINT return boolean;
   function RANGES return boolean;
   function AGGREGATE return boolean;
   function COMPONENT_ASSOCIATION return boolean;
   function ALLOCATOR return boolean;
   function NAME return boolean;
   function NAME_TAIL return boolean;
   function LEFT_PAREN_NAME_TAIL return boolean;
   function ATTRIBUTE_DESIGNATOR return boolean;
   function INTEGER_TYPE_DEFINITION return boolean;
   function DISCRETE_RANGE return boolean;
   function EXIT_STATEMENT return boolean;
   function RETURN_STATEMENT return boolean;
   function GOTO_STATEMENT return boolean;
   function DELAY_STATEMENT return boolean;
   function ABORT_STATEMENT return boolean;
   function RAISE_STATEMENT return boolean;
end PARSER_3;

------------------------------------------------------------------------------
------------------------------------------------------------------------------

package body PARSER_3 is

   -- SUBTYPE_INDICATION -->  NAME [CONSTRAINT ?]
function SUBTYPE_INDICATION return boolean is
begin
   if (NAME) then                          -- check for type_mark
      if (CONSTRAINT) then
         null;
      end if;
      return (TRUE);
```

```
   else
      return (FALSE);
   end if;
end SUBTYPE_INDICATION;

--------------------------------------------------------------------------------

   -- ARRAY_TYPE_DEFINITION -->  (INDEX_CONSTRAINT of SUBTYPE_INDICATION
   -- this function parses both constrained and unconstrained arrays
function ARRAY_TYPE_DEFINITION return boolean is
begin
   if (BYPASS(TOKEN_LEFT_PAREN)) then
      if (INDEX_CONSTRAINT) then
         if (BYPASS(TOKEN_OF)) then
            if (SUBTYPE_INDICATION) then
               return (TRUE);
            else
               SYNTAX_ERROR("Array definition");
            end if;                           -- if subtype_indication
         else
            SYNTAX_ERROR("Array definition");
         end if;                             -- if bypass(token_of)
      else
         SYNTAX_ERROR("Array definition");
      end if;                               -- if index_constraint statement
   else
      return (FALSE);
   end if;                                 -- if bypass(token_left_paren)
end ARRAY_TYPE_DEFINITION;

--------------------------------------------------------------------------------

   -- CHOICE -->  EXPRESSION [..SIMPLE_EXPRESSION ?]
   --        -->  EXPRESSION [CONSTRAINT ?]
   --        -->  others
function CHOICE return boolean is
begin
   if (EXPRESSION) then
      if (BYPASS(TOKEN_RANGE_DOTS)) then  -- check for discrete_range
         if (SIMPLE_EXPRESSION) then
            null;
         else
            SYNTAX_ERROR("Choice");
         end if;                             -- if simple_expression statement
      elsif (CONSTRAINT) then
         null;
      end if;                               -- if bypass token_range_dots
      return (TRUE);
   elsif (BYPASS(TOKEN_OTHERS)) then
      return (TRUE);
   else
      return (FALSE);
   end if;
end CHOICE;

--------------------------------------------------------------------------------

   -- ITERATION_SCHEME -->  while EXPRESSION
   --                  -->  for LOOP_PARAMETER_SPECIFICATION
function ITERATION_SCHEME return boolean is
begin
   if (BYPASS(TOKEN_WHILE)) then
      NESTING_METRIC(WHILE_CONSTRUCT);
      if (EXPRESSION) then
         return (TRUE);
      else
         SYNTAX_ERROR("Iteration scheme");
      end if;
   elsif (BYPASS(TOKEN_FOR)) then
```

```
      NESTING_METRIC(FOR_CONSTRUCT);
      if (LOOP_PARAMETER_SPECIFICATION) then
         return (TRUE);
      else
         SYNTAX_ERROR("Iteration scheme");
      end if;
   else
      return (FALSE);
   end if;
end ITERATION_SCHEME;

---------------------------------------------------------------------------

   -- LOOP_PARAMETER_SPECIFICATION -->  identifier in [reverse ?] DISCRETE_RANGE
function LOOP_PARAMETER_SPECIFICATION return boolean is
begin
   if (BYPASS(TOKEN_IDENTIFIER)) then
      if (BYPASS(TOKEN_IN)) then
         if (BYPASS(TOKEN_REVERSE)) then
            null;
         end if;                          -- if bypass(token_reverse)
         if (DISCRETE_RANGE) then
            return (TRUE);
         else
            SYNTAX_ERROR("Loop parameter specification");
         end if;                          -- if discrete_range statement
      else
         SYNTAX_ERROR("Loop parameter specification");
      end if;                             -- if bypass(token_in)
   else
      return (FALSE);
   end if;                                -- if bypass(token_identifier)
end LOOP_PARAMETER_SPECIFICATION;

---------------------------------------------------------------------------

   -- EXPRESSION -->  RELATION [RELATION_TAIL ?]
function EXPRESSION return boolean is
begin
   if (RELATION) then
      if (RELATION_TAIL) then
         null;
      end if;                          -- if relation_tail statement
      return (TRUE);
   else
      return (FALSE);
   end if;                             -- if relation statement
end EXPRESSION;

---------------------------------------------------------------------------

   -- RELATION -->  SIMPLE_EXPRESSION [SIMPLE_EXPRESSION_TAIL ?]
function RELATION return boolean is
begin
   if (SIMPLE_EXPRESSION) then
      if (SIMPLE_EXPRESSION_TAIL) then
         null;
      end if;                          -- if simple_expression_tail statement
      return (TRUE);
   else
      return (FALSE);
   end if;                             -- if simple_expression statement
end RELATION;

---------------------------------------------------------------------------

   -- RELATION_TAIL -->  [and [then ?] RELATION]*
   --               -->  [or [else ?] RELATION]*
   --               -->  [xor RELATION]*
```

```
function RELATION_TAIL return boolean is
begin
   while (BYPASS(TOKEN_AND)) loop
      if (BYPASS(TOKEN_THEN)) then
         null;
      end if;                                -- if bypass(token_then)
      if not (RELATION) then
         SYNTAX_ERROR("Relation tail");
      end if;                                -- if not relation statement
   end loop;
   while (BYPASS(TOKEN_OR)) loop
      if (BYPASS(TOKEN_ELSE)) then
         null;
      end if;                                -- if bypass(token_else)
      if not (RELATION) then
         SYNTAX_ERROR("Relation tail");
      end if;                                -- if not relation statement
   end loop;
   while (BYPASS(TOKEN_XOR)) loop
      if not (RELATION) then
         SYNTAX_ERROR("Relation tail");
      end if;                                -- if not relation statement
   end loop;
   return (TRUE);
end RELATION_TAIL;

-------------------------------------------------------------------------------

   -- SIMPLE_EXPRESSION -->  [+ ?] TERM [BINARY_ADDING_OPERATOR  TERM]*
   --                   -->  [- ?] TERM [BINARY ADDING_OPERATOR  TERM]*
function SIMPLE_EXPRESSION return boolean is
begin
   if (BYPASS(TOKEN_PLUS) or BYPASS(TOKEN_MINUS)) then
      if (TERM) then
         while (BINARY_ADDING_OPERATOR) loop
            if not (TERM) then
               SYNTAX_ERROR("Simple expression");
            end if;                          -- if not term statement
         end loop;
         return (TRUE);
      else
         SYNTAX_ERROR("Simple expression");
      end if;                              -- if term statement
   elsif (TERM) then
      while (BINARY_ADDING_OPERATOR) loop
         if not (TERM) then
            SYNTAX_ERROR("Simple expression");
         end if;                             -- if not term statement
      end loop;
      return (TRUE);
   else
      return (FALSE);
   end if;                                 -- if bypass(token_plus) et al statement
end SIMPLE_EXPRESSION;

-------------------------------------------------------------------------------

   -- SIMPLE_EXPRESSION_TAIL -->  RELATIONAL_OPERATOR  SIMPLE_EXPRESSION
   --                        -->  [not ?] in RANGES
   --                        -->  [not ?] in NAME
function SIMPLE_EXPRESSION_TAIL return boolean is
begin
   if (RELATIONAL_OPERATOR) then
      if (SIMPLE_EXPRESSION) then
         return (TRUE);
      else
         SYNTAX_ERROR("Simple expression tail");
      end if;                                -- if simple_expression statement
   elsif (BYPASS(TOKEN_NOT)) then
```

```
         if (BYPASS(TOKEN_IN)) then
            if (RANGES) then
               return (TRUE);
            elsif (NAME) then              -- check for type_mark
               return (TRUE);
            else
               SYNTAX_ERROR("Simple expression tail");
            end if;                        -- if ranges statement
         else
            SYNTAX_ERROR("Simple expression tail");
         end if;                           -- if bypass(token_in) statement
      elsif (BYPASS(TOKEN_IN)) then
         if (RANGES) then
            return (TRUE);
         elsif (NAME) then                 -- check for type_mark
            return (TRUE);
         else
            SYNTAX_ERROR("Simple expression tail");
         end if;                           -- if ranges statement
      else
         return (FALSE);
      end if;                              -- if relational_operator statement
   end SIMPLE_EXPRESSION_TAIL;

   ---------------------------------------------------------------------------

      -- TERM -->  FACTOR [MULTIPLYING_OPERATOR  FACTOR]*
   function TERM return boolean is
   begin
      if (FACTOR) then
         while (MULTIPLYING_OPERATOR) loop
            if not (FACTOR) then
               SYNTAX_ERROR("Term");
            end if;                        -- if not factor statement
         end loop;
         return (TRUE);
      else
         return (FALSE);
      end if;                              -- if factor statement
   end TERM;

   ---------------------------------------------------------------------------

      -- FACTOR -->  PRIMARY [** PRIMARY ?]
      --        -->  abs PRIMARY
      --        -->  not PRIMARY
   function FACTOR return boolean is
   begin
      if (PRIMARY) then
         if (BYPASS(TOKEN_EXPONENT)) then
            if (PRIMARY) then
               null;
            else
               SYNTAX_ERROR("Factor");
            end if;                        -- if primary statement
         end if;                           -- if bypass(token_exponent) statement
         return (TRUE);
      elsif (BYPASS(TOKEN_ABSOLUTE)) then
         if (PRIMARY) then
            return (TRUE);
         else
            SYNTAX_ERROR("Factor");
         end if;                           -- if primary(abs) statement
      elsif (BYPASS(TOKEN_NOT)) then
         if (PRIMARY) then
            return (TRUE);
         else
            SYNTAX_ERROR("Factor");
         end if;                           -- if primary(not) statement
```

```
   else
      return (FALSE);
   end if;                              -- if primary statement
end FACTOR;

--------------------------------------------------------------------------------

   -- PRIMARY -->  numeric_literal
   --         -->  null
   --         -->  string_literal
   --         -->  new ALLOCATOR
   --         -->  NAME
   --         -->  AGGREGATE
function PRIMARY return boolean is
begin
   if (BYPASS(TOKEN_NUMERIC_LITERAL)) then
      return (TRUE);
   elsif (BYPASS(TOKEN_NULL)) then
      return (TRUE);
   elsif (BYPASS(TOKEN_STRING_LITERAL)) then
      return (TRUE);
   elsif (BYPASS(TOKEN_NEW)) then
      if (ALLOCATOR) then
         return (TRUE);
      else
         SYNTAX_ERROR("Primary");
      end if;                              -- if allocator statement
   elsif (NAME) then
      return (TRUE);
   elsif (AGGREGATE) then
      return (TRUE);
   else
      return (FALSE);
   end if;                              -- if bypass(token_left_paren)
end PRIMARY;

--------------------------------------------------------------------------------

   -- CONSTRAINT -->  range RANGES
   --            -->  range <>
   --            -->  digits FLOATING_OR_FIXED_POINT_CONSTRAINT
   --            -->  delta FLOATING_OR_FIXED_POINT_CONSTRAINT
   --            -->  (INDEX_CONSTRAINT
function CONSTRAINT return boolean is
begin
   if (BYPASS(TOKEN_RANGE)) then
      if (RANGES) then
         return (TRUE);
      elsif (BYPASS(TOKEN_BRACKETS)) then          -- check for <> when parsing
         return (TRUE);                             --    an unconstrained array
      else
         SYNTAX_ERROR("Constraint");
      end if;                                   -- if ranges statement
   elsif (BYPASS(TOKEN_DIGITS)) or else (BYPASS(TOKEN_DELTA)) then
      if (FLOATING_OR_FIXED_POINT_CONSTRAINT) then
         return (TRUE);
      else
         SYNTAX_ERROR("Constraint");
      end if;
   elsif (BYPASS(TOKEN_LEFT_PAREN)) then
      if (INDEX_CONSTRAINT) then
         return (TRUE);
      else
         SYNTAX_ERROR("Constraint");
      end if;
   else
      return (FALSE);
   end if;
end CONSTRAINT;
```

```
--------------------------------------------------------------------------------

   -- FLOATING_OR_FIXED_POINT_CONSTRAINT -->  SIMPLE_EXPRESSION [range RANGES ?]
function FLOATING_OR_FIXED_POINT_CONSTRAINT return boolean is
begin
   if (SIMPLE_EXPRESSION) then
      if (BYPASS(TOKEN_RANGE)) then
         if (RANGES) then
            null;
         else
            SYNTAX_ERROR("Floating or fixed point constraint");
         end if;                               -- if ranges statement
      end if;                                 -- if bypass(token_range)
      return (TRUE);
   else
      return (FALSE);
   end if;                                   -- if simple_expression statement
end FLOATING_OR_FIXED_POINT_CONSTRAINT;

--------------------------------------------------------------------------------

   -- INDEX_CONSTRAINT -->  DISCRETE_RANGE [, DISCRETE_RANGE]* )
function INDEX_CONSTRAINT return boolean is
begin
   if (DISCRETE_RANGE) then
      while (BYPASS(TOKEN_COMMA)) loop
         if not (DISCRETE_RANGE) then
            SYNTAX_ERROR("Index constraint");
         end if;                               -- if not discrete_range
      end loop;
      if (BYPASS(TOKEN_RIGHT_PAREN)) then
         return (TRUE);
      else
         SYNTAX_ERROR("Index constraint");
      end if;                                 -- if bypass(token_right_paren)
   else
      return (FALSE);
   end if;                                   -- if discrete_range statement
end INDEX_CONSTRAINT;

--------------------------------------------------------------------------------

   -- RANGES -->  SIMPLE_EXPRESSION [..SIMPLE_EXPRESSION ?]
function RANGES return boolean is
begin
   if (SIMPLE_EXPRESSION) then
      if (BYPASS(TOKEN_RANGE_DOTS)) then
         if (SIMPLE_EXPRESSION) then
            null;
         else
            SYNTAX_ERROR("Ranges");
         end if;                               -- if simple_expression statement
      end if;                                 -- if bypass(token_range_dots)
      return (TRUE);
   else
      return (FALSE);
   end if;                                   -- if simple_expression statement
end RANGES;

--------------------------------------------------------------------------------

   -- AGGREGATE -->  (COMPONENT_ASSOCIATION [, COMPONENT_ASSOCIATION]* )
function AGGREGATE return boolean is
begin
   if (BYPASS(TOKEN_LEFT_PAREN)) then
      if (COMPONENT_ASSOCIATION) then
         while (BYPASS(TOKEN_COMMA)) loop
            if not (COMPONENT_ASSOCIATION) then
```

```
            SYNTAX_ERROR("Aggregate");
          end if;                          -- if not component association
        end loop;
        if (BYPASS(TOKEN_RIGHT_PAREN)) then
          return (TRUE);
        else
          SYNTAX_ERROR("Aggregate");
        end if;                           -- if bypass(token_right_paren)
      else
        SYNTAX_ERROR("Aggregate");
      end if;                             -- if component_association statement
   else
      return (FALSE);
   end if;                                -- if bypass(token_left_paren)
end AGGREGATE;

--------------------------------------------------------------------------------

   -- COMPONENT_ASSOCIATION -->  [CHOICE [  CHOICE]* => ?] EXPRESSION
function COMPONENT_ASSOCIATION return boolean is
begin
   if (CHOICE) then
      while (BYPASS(TOKEN_BAR)) loop
         if not (CHOICE) then
            SYNTAX_ERROR("Component asociation");
         end if;
      end loop;
      if (BYPASS(TOKEN_ARROW)) then
         if (EXPRESSION) then
            null;
         else
            SYNTAX_ERROR("Component asociation");
         end if;                          -- if expression statement
      end if;                             -- if bypass(token_arrow)
      return (TRUE);
   else
      return (FALSE);
   end if;                                -- if choice statement
end COMPONENT_ASSOCIATION;

--------------------------------------------------------------------------------

   -- ALLOCATOR -->  SUBTYPE_INDICATION ['AGGREGATE ?]
function ALLOCATOR return boolean is
begin
   if (SUBTYPE_INDICATION) then
      if (BYPASS(TOKEN_APOSTROPHE)) then
         if (AGGREGATE) then
            null;
         else
            SYNTAX_ERROR("Allocator");
         end if;                          -- if aggregate statement
      end if;                             -- if bypass(token_apostrophe)
      return (TRUE));
   else
      return (FALSE);
   end if;                                -- if subtype_indication statement
end ALLOCATOR;

--------------------------------------------------------------------------------

   -- NAME -->  identifier [NAME_TAIL ?]
   --      -->  character_literal [NAME_TAIL ?]
   --      -->  string_literal [NAME_TAIL ?]
function NAME return boolean is
begin
   if (BYPASS(TOKEN_IDENTIFIER)) then
      if (NAME_TAIL) then
         null;
```

```
         end if;
         return (TRUE);
      elsif (BYPASS(TOKEN_CHARACTER_LITERAL)) then
         if (NAME_TAIL) then
            null;
         end if;
         return (TRUE);
      elsif (BYPASS(TOKEN_STRING_LITERAL)) then
         if (NAME_TAIL) then
            null;
         end if;
         return (TRUE);
      else
         return (FALSE);
      end if;
   end NAME;

   ---------------------------------------------------------------------------

      -- NAME_TAIL -->  (LEFT_PAREN_NAME_TAIL
      --            -->  .SELECTOR [NAME_TAIL]*
      --            -->  'AGGREGATE [NAME_TAIL]*
      --            -->  'ATTRIBUTE_DESIGNATOR [NAME_TAIL]*
   function NAME_TAIL return boolean is
   begin
      if (BYPASS(TOKEN_LEFT_PAREN)) then
         if (LEFT_PAREN_NAME_TAIL) then
            return (TRUE);
         else
            return (FALSE);
         end if;                           -- if left_paren_name_tail
      elsif (BYPASS(TOKEN_PERIOD)) then
         if (SELECTOR) then
            while (NAME_TAIL) loop
               null;
            end loop;
            return (TRUE);
         else
            SYNTAX_ERROR("Name tail");
         end if;                           -- if selector statement
      elsif (BYPASS(TOKEN_APOSTROPHE)) then
         if (AGGREGATE) then
            while (NAME_TAIL) loop
               null;
            end loop;
            return (TRUE);
         elsif (ATTRIBUTE_DESIGNATOR) then
            while (NAME_TAIL) loop
               null;
            end loop;
            return (TRUE);
         else
            SYNTAX_ERROR("Name tail");
         end if;                           -- if aggregate statement
      else
         return (FALSE);
      end if;                              -- if bypass(token_left_paren)
   end NAME_TAIL;

   ---------------------------------------------------------------------------

      -- LEFT_PAREN_NAME_TAIL -->  [FORMAL_PARAMETER ?] EXPRESSION [..EXPRESSION ?]
      --                          [, [FORMAL_PARAMETER ?] EXPRESSION [..EXPRESSION ?]]*
      --                           ) [NAME_TAIL]*
   function LEFT_PAREN_NAME_TAIL return boolean is
   begin
      if (FORMAL_PARAMETER) then             -- check for optional formal parameter
         null;                               --    before the actual parameter
      end if;                                -- if formal_parameter statement
```

```
   if (EXPRESSION) then
      if (BYPASS(TOKEN_RANGE_DOTS)) then
         if not (EXPRESSION) then
            SYNTAX_ERROR("Left paren name tail");
         end if;                          -- if not expression statement
      end if;                            -- if bypass(token_range_dots)
      while (BYPASS(TOKEN_COMMA)) loop
         if (FORMAL_PARAMETER) then
            null;
         end if;                          -- if formal_parameter statement
         if not (EXPRESSION) then
            SYNTAX_ERROR("Left paren name tail");
         end if;                          -- if not expression statement
         if (BYPASS(TOKEN_RANGE_DOTS)) then
            if not (EXPRESSION) then
               SYNTAX_ERROR("Left paren name tail");
            end if;                        -- if not expression statement
         end if;                          -- if bypass(token_range_dots)
      end loop;
      if (BYPASS(TOKEN_RIGHT_PAREN)) then
         while (NAME_TAIL) loop
            null;
         end loop;
         return (TRUE);
      else
         return (FALSE);
      end if;                          -- if bypass(token_right_paren)
   elsif (DISCRETE_RANGE) then
      if (BYPASS(TOKEN_RIGHT_PAREN)) then
         while (NAME_TAIL) loop
            null;
         end loop;
         return (TRUE);
      else
         SYNTAX_ERROR("Left paren name tail");
      end if;                          -- if bypass(token_right_paren)
   else
      return (FALSE);
   end if;                           -- if expression statement
end LEFT_PAREN_NAME_TAIL;

---------------------------------------------------------------------------

   -- ATTRIBUTE_DESIGNATOR -->  identifier [(EXPRESSION) ?]
   --                      -->  range [(EXPRESSION) ?]
   --                      -->  digits [(EXPRESSION) ?]
   --                      -->  delta [(EXPRESSION) ?]
function ATTRIBUTE_DESIGNATOR return boolean is
begin
   if (BYPASS(TOKEN_IDENTIFIER)) or else (BYPASS(TOKEN_RANGE)) then
      if (BYPASS(TOKEN_LEFT_PAREN)) then
         if (EXPRESSION) then
            if (BYPASS(TOKEN_RIGHT_PAREN)) then
               null;
            else
               SYNTAX_ERROR("Attribute designator");
            end if;                    -- if bypass(token_right_paren) statement
         else
            SYNTAX_ERROR("Attribute designator");
         end if;                      -- if expression statement
      end if;                        -- if bypass(token_left_paren) statement
      return (TRUE);
   elsif (BYPASS(TOKEN_DIGITS)) or else (BYPASS(TOKEN_DELTA)) then
      if (BYPASS(TOKEN_LEFT_PAREN)) then
         if (EXPRESSION) then
            if (BYPASS(TOKEN_RIGHT_PAREN)) then
               null;
            else
               SYNTAX_ERROR("Attribute designator");
```

```
            end if;                              -- if bypass(token_right_paren) statement
         else
            SYNTAX_ERROR("Attribute designator");
         end if;                             -- if expression statement
      end if;                               -- if bypass(token_left_paren) statement
      return (TRUE);
   else
      return (FALSE);
   end if;                                 -- if bypass(token_identifier) statement
end ATTRIBUTE_DESIGNATOR;

---------------------------------------------------------------------------------

   -- INTEGER_TYPE_DEFINITION -->  range RANGES
function INTEGER_TYPE_DEFINITION return boolean is
begin
   if (BYPASS(TOKEN_RANGE)) then
      if (RANGES) then
         return (TRUE);
      else
         SYNTAX_ERROR("Integer type definition");
      end if;
   else
      return (FALSE);
   end if;
end INTEGER_TYPE_DEFINITION;

---------------------------------------------------------------------------------

   -- DISCRETE_RANGE -->  RANGES [CONSTRAINT ?]
function DISCRETE_RANGE return boolean is
begin
   if (RANGES) then
      if (CONSTRAINT) then
         null;
      end if;                                 -- if constraint statement
      return (TRUE);
   else
      return (FALSE);
   end if;                                  -- if ranges statement
end DISCRETE_RANGE;

---------------------------------------------------------------------------------

   -- EXIT_STATEMENT -->  [NAME ?] [when EXPRESSION ?] ;
function EXIT_STATEMENT return boolean is
begin
   if (NAME) then
      null;
   end if;                                  -- if name statement
   if (BYPASS(TOKEN_WHEN)) then
      if (EXPRESSION) then
         null;
      else
         SYNTAX_ERROR("Exit statement");
      end if;                                 -- if expression statement
   end if;                                  -- if bypass(token_when)
   if (BYPASS(TOKEN_SEMICOLON)) then
      return (TRUE);
   else
      return (FALSE);
   end if;                                  -- if bypass(token_semicolon)
end EXIT_STATEMENT;

---------------------------------------------------------------------------------

   -- RETURN_STATEMENT -->  [EXPRESSION ?] ;
function RETURN_STATEMENT return boolean is
begin
```

```
   if (EXPRESSION) then
      null;
   end if;
   if (BYPASS(TOKEN_SEMICOLON)) then
      return (TRUE);
   else
      return (FALSE);
   end if;
end RETURN_STATEMENT;

---------------------------------------------------------------------------

   -- GOTO_STATEMENT -->  NAME ;
function GOTO_STATEMENT return boolean is
begin
   if (NAME) then
      if (BYPASS(TOKEN_SEMICOLON)) then
         return (TRUE);
      else
         SYNTAX_ERROR("Goto statement");
      end if;                                 -- if bypass(token_semicolon)
   else
      return (FALSE);
   end if;                                   -- if name statement
end GOTO_STATEMENT;

---------------------------------------------------------------------------

   -- DELAY_STATEMENT -->  SIMPLE_EXPRESSION ;
function DELAY_STATEMENT return boolean is
begin
   if (SIMPLE_EXPRESSION) then
      if (BYPASS(TOKEN_SEMICOLON)) then
         return (TRUE);
      else
         SYNTAX_ERROR("Delay statement");
      end if;                                 -- if bypass(token_semicolon)
   else
      return (FALSE);
   end if;                                    -- if simple_expression statement
end DELAY_STATEMENT;

---------------------------------------------------------------------------

   -- ABORT_STATEMENT -->  NAME [, NAME]* ;
function ABORT_STATEMENT return boolean is
begin
   if (NAME) then
      while (BYPASS(TOKEN_COMMA)) loop
         if not (NAME) then
            SYNTAX_ERROR("Abort statement");
         end if;                               -- if not name statement
      end loop;
      if (BYPASS(TOKEN_SEMICOLON)) then
         return (TRUE);
      else
         SYNTAX_ERROR("Abort statement");
      end  if;                                -- if bypass(token_semicolon)
   else
      return (FALSE);
   end if;                                    -- if name statement
end ABORT_STATEMENT;

---------------------------------------------------------------------------

   -- RAISE_STATEMENT -->  [NAME ?] ;
function RAISE_STATEMENT return boolean is
begin
   if (NAME) then
```

```
      null;
    end if;
    if (BYPASS(TOKEN_SEMICOLON)) then
      return (TRUE);
    else
      return (FALSE);
    end if;
  end RAISE_STATEMENT;

  end PARSER_3;
```

```
--*************************************************************--
--                                                             --
--  TITLE:          AN ADA SOFTWARE METRIC                     --
--                                                             --
--  MODULE NAME:    PACKAGE PARSER_4                           --
--  DATE CREATED:   23 JUL 86                                  --
--  LAST MODIFIED:  04 DEC 86                                  --
--                                                             --
--  AUTHORS:        LCDR JEFFREY L. NIEDER                     --
--                  LT KARL S. FAIRBANKS, JR.                  --
--                                                             --
--  DESCRIPTION:  This package contains seven functions that   --
--       are the lowest level productions for our top-down,    --
--       recursive descent parser.  Each function is preceded  --
--       by the grammar productions they are implementing.     --
--                                                             --
--*************************************************************--

with BYPASS_FUNCTION, BYPASS_SUPPORT_FUNCTIONS, GLOBAL_PARSER, GLOBAL;
use BYPASS_FUNCTION, BYPASS_SUPPORT_FUNCTIONS, GLOBAL_PARSER, GLOBAL;

package PARSER_4 is
   function MULTIPLYING_OPERATOR return boolean;
   function BINARY_ADDING_OPERATOR return boolean;
   function RELATIONAL_OPERATOR return boolean;
   function ENUMERATION_TYPE_DEFINITION return boolean;
   function ENUMERATION_LITERAL return boolean;
   function FORMAL_PARAMETER return boolean;
   function SELECTOR return boolean;
end PARSER_4;

--------------------------------------------------------------------------------
--------------------------------------------------------------------------------

package body PARSER_4 is

   -- MULTIPLYING_OPERATOR -->  *
   --                      -->  /
   --                      -->  mod
   --                      -->  rem
function MULTIPLYING_OPERATOR return boolean is
begin
   if (BYPASS(TOKEN_ASTERISK)) then
      return (TRUE);
   elsif (BYPASS(TOKEN_SLASH)) then
      return (TRUE);
   elsif (BYPASS(TOKEN_MOD)) then
      return (TRUE);
   elsif (BYPASS(TOKEN_REM)) then
      return (TRUE);
   else
      return (FALSE);
   end if;
end MULTIPLYING_OPERATOR;

--------------------------------------------------------------------------------

   -- BINARY_ADDING_OPERATOR -->  +
   --                        -->  -
   --                        -->  &
function BINARY_ADDING_OPERATOR return boolean is
begin
   if (BYPASS(TOKEN_PLUS)) then
      return (TRUE);
   elsif (BYPASS(TOKEN_MINUS)) then
      return (TRUE);
   elsif (BYPASS(TOKEN_AMPERSAND)) then
      return (TRUE);
   else
```

```
      return (FALSE);
   end if;
end BINARY_ADDING_OPERATOR;

--------------------------------------------------------------------------------

   --  RELATIONAL_OPERATOR -->  =
   --                      -->  /=
   --                      -->  <
   --                      -->  <=
   --                      -->  >
   --                      -->  >=
function RELATIONAL_OPERATOR return boolean is
begin
   if (BYPASS(TOKEN_EQUALS)) then
      return (TRUE);
   elsif (BYPASS(TOKEN_NOT_EQUALS)) then
      return (TRUE);
   elsif (BYPASS(TOKEN_LESS_THAN)) then
      return (TRUE);
   elsif (BYPASS(TOKEN_LESS_THAN_EQUALS)) then
      return (TRUE);
   elsif (BYPASS(TOKEN_GREATER_THAN)) then
      return (TRUE);
   elsif (BYPASS(TOKEN_GREATER_THAN_EQUALS)) then
      return (TRUE);
   else
      return (FALSE);
   end if;
end RELATIONAL_OPERATOR;

--------------------------------------------------------------------------------

   -- ENUMERATION_TYPE_DEFINITION -->  (ENUMERATION_LITERAL
   --                                       [, ENUMERATION_LITERAL]*)
function ENUMERATION_TYPE_DEFINITION return boolean is
begin
   if (BYPASS(TOKEN_LEFT_PAREN)) then
      if (ENUMERATION_LITERAL) then
         while (BYPASS(TOKEN_COMMA)) loop
            if not (ENUMERATION_LITERAL) then
               SYNTAX_ERROR("Enumeration type definition");
            end if;                        -- if not enumeration_literal
         end loop;
         if (BYPASS(TOKEN_RIGHT_PAREN)) then
            return (TRUE);
         else
            SYNTAX_ERROR("Enumeration type definition");
         end if;                           -- if bypass(token_right_paren)
      else
         SYNTAX_ERROR("Enumeration type definition");
      end if;                              -- if enumeration_literal statement
   else
      return (FALSE);
   end if;                                 -- if bypass(token_left_paren)
end ENUMERATION_TYPE_DEFINITION;

--------------------------------------------------------------------------------

   -- ENUMERATION_LITERAL -->  identifier
   --                     -->  character_literal
function ENUMERATION_LITERAL return boolean is
begin
   if (BYPASS(TOKEN_IDENTIFIER)) then
      return (TRUE);
   elsif (BYPASS(TOKEN_CHARACTER_LITERAL)) then
      return (TRUE);
   else
      return (FALSE);
```

```
   end if;
end ENUMERATION_LITERAL;

---------------------------------------------------------------------------

   -- FORMAL_PARAMETER -->  identifier =>
function FORMAL_PARAMETER return boolean is
begin
   LOOK_AHEAD_TOKEN := TOKEN_RECORD_BUFFER(TOKEN_ARRAY_INDEX + 1);
   if (ADJUST_LEXEME(LOOK_AHEAD_TOKEN.LEXEME,
                               LOOK_AHEAD_TOKEN.LEXEME_SIZE - 1) = "=>") then
      if (BYPASS(TOKEN_IDENTIFIER)) then
         if (BYPASS(TOKEN_ARROW)) then
            return (TRUE);
         else
            SYNTAX_ERROR("Formal parameter");
         end if;                              -- if bypass(token_arrow)
      else
         SYNTAX_ERROR("Formal parameter");
      end if;                                -- if bypass(token_identifier)
   else
      return (FALSE);
   end if;
end FORMAL_PARAMETER;

---------------------------------------------------------------------------

   -- SELECTOR -->  identifier
   --          -->  character_literal
   --          -->  string_literal
   --          -->  all
function SELECTOR return boolean is
begin
   if (BYPASS(TOKEN_IDENTIFIER)) then
      return (TRUE);
   elsif (BYPASS(TOKEN_CHARACTER_LITERAL)) then
      return (TRUE);
   elsif (BYPASS(TOKEN_STRING_LITERAL)) then
      return (TRUE);
   elsif (BYPASS(TOKEN_ALL)) then
      return (TRUE);
   else
      return (FALSE);
   end if;
end SELECTOR;

end PARSER_4;
```

```
--*****************************************************************--
--                                                                 --
--  TITLE:          AN ADA SOFTWARE METRIC                         --
--                                                                 --
--  MODULE NAME:    PACKAGE SCANNER                                --
--  DATE CREATED:   06 JUN 86                                      --
--  LAST MODIFIED:  04 NOV 86                                      --
--                                                                 --
--  AUTHORS:        LCDR JEFFREY L. NIEDER                         --
--                  LT KARL S. FAIRBANKS, JR.                      --
--                                                                 --
--  DESCRIPTION:  This package reads each character from the      --
--       input buffer, determines its token class and calls        --
--       the appropriate procedure.                                --
--                                                                 --
--*****************************************************************--

with LOW_LEVEL_SCANNER, NUMERIC, GET_NEXT_CHARACTER, GLOBAL;
use LOW_LEVEL_SCANNER, NUMERIC, GET_NEXT_CHARACTER, GLOBAL;

package SCANNER is
   procedure GET_NEXT_TOKEN(TOKEN_RECORD : in out TOKEN_RECORD_TYPE);
end SCANNER;

---------------------------------------------------------------------------
---------------------------------------------------------------------------

package body SCANNER is

procedure GET_NEXT_TOKEN(TOKEN_RECORD : in out TOKEN_RECORD_TYPE) is
begin
   LEXEME_LENGTH := 1;
   for I in 1..LINESIZE loop
      TOKEN_RECORD.LEXEME(I) := ' ';
   end loop;

   GETNEXTCHARACTER(NEXT_CHARACTER, LOOKAHEAD_ONE_CHARACTER);

   if ((NEXT_CHARACTER in UPPER_CASE_LETTER) or
      (NEXT_CHARACTER in LOWER_CASE_LETTER)) then
      TOKEN_RECORD.TOKEN_TYPE := IDENTIFIER;
      GET_IDENTIFIER(TOKEN_RECORD);

   elsif ((NEXT_CHARACTER = ' ') or
      (character'pos(NEXT_CHARACTER) in FORMATORS)) then
      TOKEN_RECORD.TOKEN_TYPE := SEPARATOR;
      FLUSH_SEPARATORS(TOKEN_RECORD);

   elsif (NEXT_CHARACTER in DIGITS_TYPE) then
      TOKEN_RECORD.TOKEN_TYPE := NUMERIC_LIT;
      GET_NUMERIC_LIT(TOKEN_RECORD);

   elsif ((NEXT_CHARACTER = '-') and (LOOKAHEAD_ONE_CHARACTER = '-')) then
      TOKEN_RECORD.TOKEN_TYPE := COMMENT;
      FLUSH_COMMENT(TOKEN_RECORD);

   elsif (NEXT_CHARACTER = ''') then
      TOKEN_RECORD.TOKEN_TYPE := CHARACTER_LIT;
      GET_CHARACTER_LIT(TOKEN_RECORD);

   elsif ((NEXT_CHARACTER = '|') or (NEXT_CHARACTER = ' ') or
      (character'pos(NEXT_CHARACTER) in DELIMITER1) or
      (character'pos(NEXT_CHARACTER) in DELIMITER2)) then
      TOKEN_RECORD.TOKEN_TYPE := DELIMITER;
      GET_DELIMITER(TOKEN_RECORD);

   elsif (NEXT_CHARACTER = '"') then
      TOKEN_RECORD.TOKEN_TYPE := STRING_LIT;
      GET_STRING_LIT(TOKEN_RECORD);
```

```
   elsif (NEXT_CHARACTER = '$') then
      TOKEN_RECORD.TOKEN_TYPE := SEPARATOR;     --input was a blank line
      TOKEN_RECORD.LEXEME(CURRENT_BUFFER_INDEX) := '$';
      NEXT_BUFFER_INDEX := REFILL_BUFFER_INDEX;

   elsif (character'pos(NEXT_CHARACTER) = 0) then     --first character is null
      TOKEN_RECORD.TOKEN_TYPE := SEPARATOR;
      NEXT_BUFFER_INDEX := REFILL_BUFFER_INDEX;       --force buffer to refill
   else
       -- first character read is not one of the legal characters
      TOKEN_RECORD.TOKEN_TYPE := ILLEGAL;
      ERROR_MESSAGE(TOKEN_RECORD.TOKEN_TYPE);
   end if;

--  token value is an integer which corresponds to the token type's
--     position in the token list
   TOKEN_RECORD.TOKEN_VALUE := TOKEN'pos(TOKEN_RECORD.TOKEN_TYPE);
   TOKEN_RECORD.LEXEME_SIZE := LEXEME_LENGTH;
end GET_NEXT_TOKEN;

end SCANNER;
```

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